THE UNIVERSITY OF ALBERTA

# CONSERVATION AND PHENOMENAL-REAL DISCRIMINATION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Conservation and Phenomenal-Real Discrimination", submitted by Lester Prokopczak in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

A study was carried out to investigate conservation and phenomenal-real discrimination in primary school children with the intention of observing possible correlates between the two abilities. The research was designed as a cross-sectional developmental study with age and conservation status (presence or absence of conservation) comprising the major independent variables.

A sample of seventy-five children was selected at random from ten classrooms within the public school system of Edmonton, Alberta. All subjects were female and twenty-five subjects were allocated to each of three age groups (six and one half to seven and one half years; seven and one half to eight and one half years; eight and one half to nine and one half years). Subjects not displaying a consistent response to a particular conservation pretest were not included in the sample. Conservation pretests were concerned with length, area, mass, and continuous quantity of liquid.

The study was divided into four parts as follows:

(1) Age and conservation status groups were compared on age, I.Q. (Detroit Beginners Intelligence Test), and socio-economic status (Blishen Occupational Class Scale). In addition, the conservation status groups were analyzed on the basis of their responses to tasks about quantitative equivalence which allowed a mere visual comparison of objects. The objects in each task were

identical to the objects present in the final stage of respective conservation tasks. The main hypothesis tested was that on the basis of a mere visual comparison nonconservers would be more susceptible than conservers in acknowledging inequality between quantitatively equivalent concrete objects of different shapes.

(2) Part two was concerned with comparing age and conservation status groups (length only) on eye movements during the examination of the Muller-Lyer illusion. The major hypotheses tested that types of verbal instruction would influence scanning behavior and that conservers and older age groups would display greater decentration in their visual examination of the illusion stimulus than younger subjects and nonconservers.

(3) Age and conservation status groups were tested on phenomenal-real discrimination tasks. The major hypothesis tested was that conservers would not be as susceptible as nonconservers to phenomenal-real discrepancies.

(4) Part four was designed as an intervention study where twenty nonconservers were trained for conservation of length, mass, and area while twenty nonconservers were used as a control. The major hypothesis tested was that an intensive training session could foster the acquisition of conservation in nonconservers.

The major results of the study were:

(1) In part one, nonconservers were more susceptible than conservers in acknowledging quantitative inequality in concrete objects on the basis of a mere visual comparison.

(2) There were no significant differences in scanning behavior due to the type of verbal instruction. The age and conservation status groups did not display differences in decentration.

(3) There was no difference between the responses of conservers and nonconservers on the phenomenal-real discrimination tasks.

(4) Subjects in the training group showed significant gains over subjects in the control group in acquiring conservation.

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# CHAPTER I

# INTRODUCTION

## General Problem and Overview

The thesis was primarily concerned with testing a rationale and procedure developed by the author for instilling conservation in nonconservers. The basic rationale involved the utilization of phenomenal-real discrimination as an orienting basis for fostering conservation acquisition. An emphasis was placed on the simultaneous consideration of purely quantitative transformations and the misleading aspects of perceptual cues. The results indicated that the training procedure was highly successful in developing an understanding of the quantitative concepts inherent in conservation problems for subjects in the treatment group.

Two subsidiary goals in the thesis were concerned with testing whether nonconservers possessed the ability of phenomenal-real discrimination and whether both state attributes (perceptual features of objects) and transformations involved on objects in conservation tasks were factors in directing the nonconserver's responses to such tasks. The results indicated that nonconservers did possess the ability of phenomenal-real discrimination and that both state attributes and transformations were factors influencing the nonconserver in his solution of the conservation problems.

A third subsidiary goal in the thesis was concerned with

comparing age and conservation status groups for differences in perceptual activity (eye movements) during visual scanning of the Muller-Lyer illusion. No differences were observed in perceptual activity between any of the groups. Conclusions regarding the analysis of the eye movements were considered tentative pending a further analysis of the data in terms of a definition of visual fixation incorporating a variable latency.

Definitions

1. Conservation: The understanding that the quantity of objects remains invariant in the face of changes in other attributes.

2. Fixation: (i) Locus on a visual stimulus receiving the most vivid recording by the eye.

(ii) One corneal reflection recorded at a rate of 10 per second.

3. "Phenomenal-Real"Discrimination: The ability to distinguish between the appearance of phenomena and their characteristics as measured by some physical scale.

4. Illusion: A stimulus situation possessing a "phenomenal-real" discrepancy.

5. Perceptual Activity: Behavior on the part of the organism to attend to (perceive) the various parts of a total stimulus configuration.

6. Centration: Fixation on a particular locus of a stimulus configuration.

7. Decentration: Shift in fixation from one particular locus of a stimulus configuration to another particular locus.

8. Eye Movement: An agent of decentration for visual perceptual activity.

9. Track Length: The distance (as measured on a flat plane) between one fixation and another which has either preceded or followed the fixation.

10. Orienting Behavior: The directing of attention (voluntary) to aspects of stimuli.

# CHAPTER II

## THEORETICAL BACKGROUND

Piaget's formulations on mental development, especially his concepts of conservation, have generated much research and discussion amongst psychologists and educators. Not only is the rationale for conservation acquisition being challenged theoretically but also, debate is centered on the question of whether conservation acquisition must await a gradual naturalistic process of development (Ausubel, D.P., 1966; Beilin, H., 1964, 1965; Bittner, A.C. and Shinedling, M.M., 1968; Braine, M.D.S., 1959, 1964; Braine and Shanks, 1965; Brison, D.W. and Sullivan, E.V., 1967; Bruner, J.S., 1966; Bruner, Olver and Greenfield, 1966; Elkind, D., 1961, 1962, 1964, 1967; Feigenbaun, K.D., 1963; Gelman, R.S., 1967; Green, G.E., 1965; Griffiths, J.A., Shantz, C.A. and Sigel, I.E., 1967; Gruen, G.E., 1966; Halford, G.S., 1968; Halpern, E., 1965; Hermeier, R.K., 1968; Hood, H.B., 1962; Kingsley, R.C. and Hall, V.C., 1967; Kohnstamm, G.A., 1963, 1967; Larsen, R.M., 1967; Lee, P.C., 1967; Lovell, K. and Ogilvie, E.A., 1961; Mays, W., 1953; Mermelstein, E. and Shulman, L.S., 1967; Murray, F.B., 1965, 1966; Peel, E., 1959; Peisach, E., 1967; Piaget, J., 1955, 1956, 1960; Plufall, P.B., 1967; Saltz, E. and Hamilton, H., 1968; Smedslund, J., 1961, 1961(b); Sullivan, E.V., 1966; Uzgires, I.E., 1964; Wallace, L. and Sprott, R.L., 1964; Wohlwill, J.F., 1960, 1962, 1967; Zimiles, H., 1963).

Piaget uses the term "conservation" as follows:

> "We shall use the term "conservation" for notions which appear at about 7 or 8 years of age, and which affirm the existence of quantitative invariants. The conservation of substance, of weight, etc., thus deal with quantities of matter or weight. The conservation of a group, in the logical or mathematical sense, when the distribution of the parts or the sub-groups has been modified, deals with the "extension" of the group, that is, with the quantity of individual objects which make up the group."
>
> "But on the other hand, precisely because they are quantitative, notions of conservation always deal with invariants which are based on the composition of certain transformations, so that we can say that where there is no transformation we cannot speak of conservation."
>
> "Conservation is possible only when there is composition of quantitative variations, which can take the form of a compensation of relations (higher X thinner = the same amount), or simply of an additive composition (nothing added, nothing taken away = the same amount)."
>
> (Piaget, 1968, p. 18-19.)

For Piaget, conservation emerges with the onset of the stage of concrete operations.

> "the crucial turning-point for the beginning of operations shows itself in a kind of equilibration, which is always rapid and sometimes sudden which affects the complex of ideas forming a single system and which needs explaining on its own account."
>
> "where there is a 'grouping': there will be the conservation of a whole, and this conservation itself will not merely be assumed by the subject by virtue of a probable induction, but affirmed by him as a certainty in his thought."
>
> "The grouping thus realizes for the first time an equilibration between the assimilation of objects to the subject's action and the accommodation of subjective schemata to modifications of

> objects. At the outset, in fact, assimilation and accommodation act in opposite directions; hence the distorting character of the first and the phenomenalist character of the second. By means of anticipations and reconstitutions, which extend action in both directions to ever increasing distances, from the brief anticipations and reconstitutions characteristic of perception, habit and sensori-motor intelligence to the anticipatory schemata formed by intuitive representation, assimilation and accommodation are gradually equilibrated. The completion of this equilibration explains the reversibility which is the final term of sensori-motor and mental anticipations and reconstitutions, and with it the reversible combinativity which is the distinguishing mark of the grouping".
>
> (Piaget, 1960, p. 139-143.)

The five conditions of the grouping which are crucial for the attainment of conservation are described by Piaget are as follows:

I. Combinativity: $x + x^1 = y$; $y + x^1 = z$; etc.

II. Reversibility: $y - x = x^1$ or $y - x^1 = x$.

III. Associativity: $(x + x^1) + y^1 = x + (x^1 + y^1) = (z)$.

IV. General operation of identity: $x - x = 0$; $y - y = 0$; etc.

V. Tantological or specific identities:

$$x + x = x; \quad y + y = y; \text{ etc.}$$

(Piaget, 1960, p. 42).

Piaget (1967) feels that common misrepresentations of his position, as evidenced by his criticism of Bruner's work on conservation, are as follows:

1. Confusing pseudo-conservation with true conservation (lack of applying an "operational conservation" check on the subject's response to a conservation task).

2. Confusing co-variance of dimensions with compensation (co-variance, observation that a change in one dimension is

related to a change in another dimension, can be acquired without comprehension by direct perceptive recordings).

3. Confusing renversabilité (empirical return) with reversibility (operatory concept).

Piaget also argues that the concept of identity and its relationship to conservation has been misunderstood by experimenters (Bruner, Olver and Greenfield, 1966) who emphasize qualitative identity instead of quantitative identity (see Specific Aims and Rationale, Part IV).

Criticisms, however, have also been made on Piaget's formulations by others. Elkind (1967) has mentioned that conservation tasks involving one object differ from tasks containing two or more objects. Conservation of identity is said to be measurable directly in the former tasks and only inferred in the latter ones. Although the author does not necessarily agree with Elkind's interpretation, it clarifies Piaget's use of the "equation of differences" in his interpretation of conservation. More effective arguments against Piaget's formulations come from Berlyne (1965) and Ojemann and Pritchett (1966). Besides concluding that quantitative invariance is not based on an understanding of compensation, Berlyne (1965) makes the more important criticism that Piaget uses reversibility procrusteanly.

> "Finally, Piaget (1949a) states that, in logic, the reversibility relation is the foundation of all consistency in the form of the law of contradiction. This law states that a proposition, p, and its denial, not-p, cannot both be true. In other words, logical thinking requires a recognition of an inverse relation between two incompatible propositions, each of which entails the nonvalidity of the other.

In this case, contradiction or impossibility has to be regarded as a null element. But it does not conform to the definition of a null element given in the second rule defining groups. To assert a proposition, p, together with some other proposition that is contradictory or impossible is hardly equivalent to asserting p alone."

(Berlyne, 1965, p. 209).

Kohnstamm feels that the general opinion generated about the lack of success of experiments designed to train for conservation acquisition should not be in support of Piaget's contention that intervention studies will be unsuccessful but against the nature of the chosen didactics in the experiments (Ojemann and Pritchett, 1966). Kohnstamm states that Piaget considers three criteria as essential for testing whether the newly acquired behavior patterns (conservations) are of the required quality (not merely pseudo-conservations).

The acquired behavior should be

1. lasting
2. transferable
3. fundamentally different from the pre-experimental level of behavior.

Kohnstamm discusses these three criteria as follows:

"As to the first criterion, which we shall name durability, Piaget's opinion is that "if a structure develops spontaneously, once it has reached a state of equilibrium, it is lasting; it will continue throughout the child's life."

"Although I have used this criterion myself, I do not think it to be a very important one. Why is it necessary for the child to remember without training or repetition? The learned behavior usually bears no relation to daily life, so the child will very seldom use the newly acquired "operation". In Piaget's theory the postulated underlying

structure develops because of the need for the child to use it in daily practice. The fact that he is able at some time to solve the Piagetian problems in a so-called "clinical" experiment proves that the underlying structure has been developed.

But what if this postulation of a gradual developing system of underlying structures were false? And what if the child one day solves the problem because in fact: 1) He has learned in daily life to use language to such a level as to be helpful in handling misleading perceptual cues. (See Wohlwill, Cornell Conference, 1964.) 2) He structures his thought at the very moment of being confronted with the necessity of doing so (Aebli, 1963)? If these explanations were truer than Piaget's, remembering without further reinforcement would be a less important criterion for the quality of the acquired behavior. Therefore, the criterion of durability presupposes that Piaget's theory is true. This makes it a doubtful criterion when testing the theory.

The second criterion of transfer or generalization is a widely accepted criterion for the quality of a learning result. Here too: the more the better. But exactly how much transfer is needed in a Piagetian quality test? The answer can only be either theoretical and vague or empirical, based upon examples of Genevan experimental practice.

The Piagetian theoretical answer is heavily loaded with the presupposition of the truth of Piaget's theory about the organization of the mind in structures d'ensemble. If, for instance, Bovet and Pascual-Leone (1966) try to refute my experimental results (Kohnstamm, 1963) by saying that I did not prove that the subjects, after having learned behavior a were automatically able to perform a behavior b, c and d, all related to the same underlying structure S, they presuppose that this structure S actually exists and is really responsible for the existence of a so-called "grouping of operations." Greco (1959) noticed this to be a presupposition and as a result has not used a theoretically derived transfer test in checking the quality of his experimental results.

> I will not linger over the criterion of the difference between pretest and posttest behavior, because this difference is implicit in the above-mentioned difference between training and transfer (the child is being trained to change his pretest behavior into a qualitatively different posttest behavior)."
>
> (Ojemann and Pritchett, 1966, p. 59-62).

With respect to the development of rationales for training methods concerned with conservation acquisition, several alternative proposals have been put forth (Bruner, Olver and Greenfield, 1966; Wohlwill, 1962; Wallace and Sprott, 1964; Gelman, 1967; Kohnstamm, 1963; Brison and Sullivan, 1967; Gruen, 1966; Smedslund, 1961; Braine, 1964; Murray, 1966; Kingsley and Hall, 1967; Lefrancois, 1966). Smedslund has attempted to show that a cognitive conflict model (one where the subject is focused on contradictory conclusions to clarify his concepts) is more effective than a method emphasizing "reinforcement" in fostering conservation acquisition. Kingsley and Hall (1967) have investigated (with mediocre results) the use of "set" in training for conservation. Popular consensus has been to consider that misleading perceptual cues in conservation tasks are an important factor in causing the nonconserver to rationalize his response. Subsequently attempts have been made by experimenters such as Bruner, Olver, Greenfield (1966) and Wohlwill (1962) to de-emphasize such cues in the hope that the nonconserver will be freed from his former reliance on state attributes (perceptual features of objects). The roles of verbal instruction and verbal responses used in conservation tasks has also caused much controversy as evidenced by experiments such as Braine (1964), Kohnstamm (1963) and Bruner, Olver, Greenfield (1966). Perhaps the

more encompassing approaches have been by Gelman (1967) and Sigel and Roeper (1967) who emphasize that attention must be paid to both state attributes (perceptual features) and to transformations carried out on such state attributes. More specifically, they argue that only by emphasizing the relevant aspects of the conservation task (nature of the transformation) and de-emphasizing the irrelevant aspects (perceptual features) can there be hope for success in teaching conservation to nonconservers. Other approaches have been to emphasize some part of the grouping formulated by Piaget (such as reversibility, compensation, identity) as a part of the training session (Brison and Sullivan, 1967; Murray, 1966; Bruner, Olver and Greenfield, 1966). Braine and Shanks (1965) have proposed that a close relationship exists between conservation and phenomenal-real discrimination,to the effect that a general distinction between real and phenomenal properties of objects is the basis of the conservations. Murray (1966) has initiated a training session incorporating the use of objects displaying phenomenal-real discrepancies and manipulations emphasizing reversibility. As evidenced by the proliferation of studies on conservation training as well as by the various theoretical proposals about conservation acquisition, no strikingly effective method exists as yet to foster conservation acquisition. It may be that eventually several different approaches will be successful. However, Piaget's position on the nature of conservation acquisition and his opinion of the role that teaching can play in effecting cognitive development are still valid arguments.

In attempting to train the nonconserver in conservation, the role of states and transformations should be considered (as done

by Sigel and Roeper, 1967). Although the key factor in the nonconserver's lack of conservation is one of inadequate reasoning (as Piaget, 1960, p. 130, has maintained) the nonconserver cannot know that he lacks conservation since he has no conception of true conservation. In order for the nonconserver to become aware of and motivated towards learning true conservation he must first question and reject some of his existing assumptions about the relationships between perceptual states, changes in perceptual states, and purely quantitative transformations. Evidence in support of the above contention comes from experiments which have indicated that the nonconserver is susceptible to misleading perceptual states of objects and their associated transformations (Bruner, Olver and Greenfield, 1966; Berlyne, 1965; Gelman, 1967; Wallace and Sprott, 1964; Wohlwill, 1960, 1962; Zimiles, 1963).

Misleading perceptual cues arise from two sources which may or may not be in interaction. Differences exist in perceptual features of objects due to differences in dimensions, shape, texture, color, spatial position and temporal occurrence, etc.). A second category of perceptual discrepancies is often closely related to the former--that of illusory effects. Not only could the nonconserver's response on the conservation tasks (in terms of rationalizing his nonconservation response) be related to the perceptual features of the objects and the transformations involved on these objects but also the specific effect of illusory discrepancies could alternate between the transformed and untransformed objects for particular tasks causing further misleading cues for the nonconserver. It is therefore relevant to consider whether the conserver has two advantages over the nonconserver. Not

only may the conserver possess a superior concept to that of the nonconserver's, but the conserver may also possess a superior resistance to misleading perceptual cues (if the presence of operational structures influence the subject's perceptual activity so as to cause increased decentration in visual scanning behavior). Although it may be argued that the conserver does not require information based on perceptual activity since he answers the conservation problem in terms of a logical concept, there is evidence that even the conserver will regress to giving a nonconservation response if the phenomenal-real discrepancies or the novelty of the task is great enough (Halpern, 1965; Murray, 1966). Regardless of the above consideration, an examination of the perceptual activity displayed by conservers and nonconservers would provide an interesting test on Piaget's statements about the partial isomorphisms between perception and intelligence. If the conserver possesses concepts which allow systematic comparisons of all elements included in a whole (e.g. reversibility, combinativity, associativity) then perhaps the possession of such intellectual structures implies that perception as evidenced by perceptual activity is guided or influenced by them. If conservers do not demonstrate more decentration of visual scanning over the stimulus areas than the nonconservers (on stimuli concerned with visual comparison of their parts but not in terms of a conservation task since the conservers' perceptual activity need not exist) then Piaget's argument for the existence of partial isomorphisms between perception and intelligence would be weakened. Comparing conservers and nonconservers on phenomenal-real discrepancies (where the objects in question only

differ in terms of one perceptual cause--an illusion without actual differences in shape or position) where recordings of visual scanning (eye movements) could take place would provide a particular test on the above hypothesis. A comparison of the perceptual activity of conservers and nonconservers on conservation tasks would possibly indicate no differences or else much less perceptual activity on the part of the conserver in response to the task required.

The findings of Yarbus (1967) indicate that stimuli possessing strong phenomenal-real discrepancies tend to direct visual scanning rather than vice versa. If such is the case a comparison of conservers and nonconservers (for differential effects of the grouping on perceptual activity--causing greater field articulation and scanning) would test whether the conservers are more resistant to the influences of the illusion (e.g. a greater spread of fixations on the feather of the Muller-Lyer illusion). Also a test could be provided on whether verbal instructions differentially induce the formation of a "standard" in terms of greater visual concentration (Piaget, 1960; Flavell, 1963; Gardner and Long, 1961).

CHAPTER III

# SPECIFIC AIMS AND RATIONALE

## Part I

The two primary aims were the selection and classification of the sample and the testing of the subjects on tasks involving comparisons of quantity in concrete objects.

With regard to the first objective, consideration had to be made for sample requirements in all four parts of the thesis because most of the subjects were to be used in more than one part. Since the two major independent variables considered throughout the thesis were age and conservation status, subjects were selected within the age range indicative of the early period of concrete operations (Piaget, 1960; Flavell, 1963). Also, in keeping with the sample requirements for part four of the thesis (see Specific Aims and Rationale--Part IV) it was necessary to select subjects who already possessed the ability of phenomenal-real discrimination (Braine and Shants, 1965; Murray, 1966). Finally, from a practical aspect, the feasibility of using subjects for eye movement recordings in part two of the thesis (in terms of dental development and attention span) confirmed the choice of age range for the sample. In addition to age, the sample was further classified into groups of conservers and non-conservers. This was carried out separately for each of the conservation tasks of length, area, mass and continuous quantity of liquid. Although the conservation of length was the predominant interest in the

Study (see Specific Aims and Rationale--Part II and Part IV), the other types of conservation tasks were included in connection with the second primary aim in part one and the training session in part four.

The second primary objective in part one was to compare the responses of conservers and nonconservers on conservation and stage C tasks. The latter tasks may be represented as follows:

| | | | Response | |
|---|---|---|---|---|
| | | | Conserver | Nonconserver |
| Conservation task | Stage A (actual quantitative and qualitative equality) | $S_1=S_2$ $\downarrow$ | = | = |
| | Stage B | T $\downarrow$ $S_{2A}$ | | |
| | Stage C (actual quantitative equivalence) | $S_1=S_{2A}$ | = | ≠ |
| Stage C task | (actual quantitative equivalence) | $S_1=S_{2A}$ | ? | ? |

$S_1$ = concrete object     T = transformation

$S_2$ = concrete object     $S_{2A}$ = transformed object

The stage C tasks involved a quantitative comparison of objects similar to those present in the final stage of a corresponding conservation task except that there was no knowledge of prior equality between the objects or evidence of a transformation being performed on one of the objects. In other words, the stage C tasks could only be solved on the basis of a mere visual comparison. It is apparent that in a stage C task, where $S_1$ and $S_{2A}$ are presented in isolation without the prior knowledge provided in conservation tasks, there is no basis for a firm confirmation of quantitative equality. In fact, the subject is most likely at a disadvantage due to the presence of an illusion created by the "state" attributes of the objects (shape, relative position, texture, etc.). Evidence for such phenomenal-real discrepancies has been provided by Elkind (1967), Beilin (1964) and Piaget (1960).

It was hypothesized that an analysis of the responses to the conservation and stage C tasks would provide information about the nonconserver in terms of the factors contributing to his decision that objects in the final stage of a conservation task are quantitatively unequal. The following factors are possible reasons for a subject's response to a conservation task:

A. Stereotyped response
B. Guessing
C. Lack of communication between experimenter and subject
D. Type of transformation
E. Illusion effect or phenomenal-real discrepancy
F. Focusing on aspects of stimuli which are irrelevant (e.g. comparing extremities of a straight and curved line as a basis for length equivalence)
G. Logical inference.

The possibility of an interaction between some of the above factors must not be excluded but for the purposes of this thesis the factors were considered separately.

In the solution of a stage C task, the possible influence of factors D and G are eliminated and since factors A, B and C should be removed by the experimental design, only factors E and F remain as sources of a response about quantitative inequality between the concrete objects. Alternatively, in the conservation tasks the nonconserver will have one more factor at his disposal in terms of the type of transformation (factor D). Again, factors A, B and C will have been removed as a result of experimental design and factor G will not be used by the nonconserver. In comparing responses to conservation and stage C tasks (in terms of susceptibility to acknowledge inequality and the particular object chosen as e.g. "more") it thus becomes possible to test if certain objects are considered to have "more" quantity than others in a stage C task (where the factors E and F are operating) and to compare such responses for consistency when conservation tasks are presented. If no difference is apparent between object choice in the stage C and conservation tasks, then it can be inferred that the transformation occurring in the conservation task is not the significant factor (factor D) in influencing the nonconserver's response. Rather, the factors E and F are the major determinants. However, if a significant change in object choice occurs for the nonconservers from the conservation tasks to the stage C tasks, then it can be inferred that the transformation factor (factor D) is important in determining the nonconserver's decision about quantitative inequality between the objects.

It was the author's opinion that in certain conservation tasks factors E and F would be predominant (conservation of liquid continuous quantity) while in other types of conservation tasks factor D (type of transformation) would be influencing the nonconserver's decision (conservation of area). It was further concluded and adopted in part four of the thesis that for conservation acquisition both "state" effects (factors E and F) and the type of transformation (factor D) would play a vital role. The implications of the above discussion are that the states of the objects as well as the transformations involved first play a vital role in leading the nonconserver to make errors on the conservation tasks but that at the same time, as it will be demonstrated in part four of the thesis, to attain conservation a refocusing of attention is necessary on the states of the objects and the accompanying transformations both of which can contribute to the acquisition of logical inference (Sigel and Roeper, 1967; Berlyne, 1965; Sawada, 1966; Zimiles, 1963).

# PART II

From the considerations dealt with in Part I (Specific Aims and Rationale) it can be concluded that the reasons for a nonconserver's choice of object (as being either quantitatively more or less than the other accompanying object in a conservation task) may be related to three factors:

1. consideration of the transformation performed on one of the objects;

2. consideration of the discrepancy in the non-illusory perceptual attributes of the objects;

3. consideration of the discrepancy in the illusory attributes of the objects.

It is difficult to ascertain which of the factors (or which combination of factors) plays a predominant role in particular conservation tasks. The aim of Part II was to isolate one of these factors (illusory discrepancies between objects) and study it further in terms of object choice and perceptual activity. In a task involving a mere visual comparison, subjects (age and conservation status groups) were to compare two objects demonstrating a phenomenal-real discrepancy. The choice of an object (as either possessing more or less quantity) was to be analyzed in terms of the subjects' perceptual activity (visual scanning of the stimuli). It was intended to investigate whether the choice of object was related to the amount (number of fixations) and extent (track length) of visual comparison on the objects.

Also, the amount of scanning of the total stimulus array (in terms of number of fixations and track length) was to be compared over different verbal instructions (ambiguous instructions compared to specific instructions).

The rationale behind the above aims was based on theoretical considerations and experimental findings that maintained differences in perceptual activity existed between earlier and later stages in psychological development. In terms of the Piagetian thesis (Piaget, 1961, 1960, 1958; Flavell, 1963; Gardner and Long 1962, 1961) partial isomorphisms exist between the development of perception and intelligence. The semireversibility of perceptual structures is partially isomorphic to the full reversibility of intellectual (operational) structures. Also, the "preinferences" in perceptual activity show partial isomorphisms with the logical inferences of operational thought. Perceptual activity in terms of increasing decentration over aspects of stimulus arrays increases with age. The apparent differences in cognitive structure between conservers and nonconservers (Piaget, 1960) could also be related hypothetically to differences in the perceptual activity of conservation status groups. It could be argued that the attainment of cognitive structures containing full reversibility could influence the perceptual activity of subjects. Gardner and Long (1961) have termed two cognitive control principles (Field Articulation and Scanning) as dimensions representing structural aspects of ego organization. Differences in perceptual activity on particular discrimination tasks are related to these cognitive strategies.

The experimenter was interested in observing whether age and conservation status groups would display differences in decentration during the viewing of the Muller-Lyer illusion stimulus. As a pilot study, the analysis of eye movements in the Muller-Lyer illusion could pave the way for further studies comparing the perceptual activity of age and conservation status groups on phenomenal-real discrimination tasks involving mere visual comparisons of objects and other tasks involving the presence of transformations on state attributes (perceptual features of objects) as Murray (1966) has used with desk presentations (illusion length conservation tasks). The author's opinion was that although age and conservation status groups could have differed in possessing different cognitive structures, the perceptual activity on the Muller-Lyer illusion would not tend to differ amongst the groups. As Yarbus (1967) has indicated, stimuli possessing strong phenomenal-real discrepancies tend to control the scanning of the eye rather than vice versa. The results in Chapter IV, Part II are in support of such a contention. It would be of optimal interest to test the effects of illusory discrepancies on the perceptual activity of age and conservation status groups during the presentation of illusion length conservation tasks. In the latter case the two additional factors of object transformation and the availability of using logical inference could cause specific changes in the perceptual activity involved with the scanning of the Muller-Lyer illusion. Specific changes need not occur, however, since the novelty of transforming an object should create orienting reactions towards it in all cases (during the transformation). Furthermore, as demonstrated in Chapter IV, Part II, the latency of scanning need not differ between

conservers and nonconservers since the discrimination required in an illusory situation would be simple (with the exception of illusion strength studies).

Alternative studies investigating the perceptual activity of age and conservation status groups on conservation tasks involving both illusory and non-illusory perceptual features (as presented in Chapter IV, Part I) could investigate if a correspondence existed between subject choice (in particular, the object considered as more by the nonconservers) and the location of fixation concentration (on one object or the other). For instance, if the results of Part I (in terms of object choice on particular conservation tasks) were substantiated (at times the transformed object was considered to have more quantity and at times the non-transformed object was considered to have more) and yet the concentration of fixations was consistently on the transformed object, Piaget's formulations about the "error of the standard" (Piaget, 1960) would be questioned since the centrated object should be magnified.

The definition of fixation as used in the thesis was defined as follows:

Fixation = one corneal reflection recorded at 10 corneal reflections per second.

Number of Fixations = X = sum of corneal reflections recorded per trial of stimulus presentation (maximum of 100).

The definition of mean track length as used in the thesis was defined as follows:

$$\text{Mean track length} = \frac{\text{sum of the distances calculated in millimeters between successive fixations}}{X - 1}$$

The author concluded that after an analysis of the data in terms of the above definitions a reanalysis of data would be warranted in terms of a definition of fixation allowing for variable latency. The latter analysis was not included in the thesis.

# PART III

The primary aim of part III was to compare conservers and nonconservers on tasks involving phenomenal-real discrimination. Such a decision was reached as a result of considering several studies in this area (Braine and Shanks, 1965; Murray, 1966; Beilin, 1964; and Elkind, 1966) and a need to check the testability of the author's own hypotheses about the role of phenomenal-real discrimination as an orienting basis for fostering conservation acquisition in a training session (see Specific Aims and Rationale, Part IV). With reference to the latter point, only if the subjects (nonconservers) who were to be trained for conservation acquisition already possessed phenomenal-real discrimination would they be suitable as subjects in the training session. Thus, the nonconservers who did not possess phenomenal-real discrimination could not benefit (theoretically) from the training session since a crucial aspect of the training required that the subjects understand the distinction between the apparent (phenomenal) and real aspects of a situation. For the training session to have been relevant to the nonconservers who lacked phenomenal-real discrimination would have been necessary. It was thus necessary to determine whether the nonconservers in the sample were legitimate candidates for the training session. It was felt that due to the age range of the subjects in the sample a high probability existed that most if not all subjects would possess phenomenal-real discrimination. This assumption was based on the experimental findings of (Murray, 1966),

and Braine and Shanks (1965) where the emergence of phenomenal-real discrimination was found to be present as early as five years of age.

The author was also interested in whether the proposal made by Braine and Shanks (1965) stating:

> "the conservations are a direct manifestation of the development of a broad conceptual distinction between real and phenomenal properties of objects,"

would be substantiated with the present sample. It was the author's own feeling that many subjects who possessed phenomenal-real discrimination would not possess conservation (see Specific Aims and Rationale, Part IV).

Another interesting hypothesis put forth by Murray (1966) was

> "length conservation rests upon a general phenomenal-real discrimination in questions of length, but not simply a general phenomenal-real discrimination capacity itself."

This would imply that the relationship between conservation and phenomenal-real discrimination would be specific for each type of dimension or task (length, area, volume, number, etc.). To test this latter hypothesis the author included tasks of length and area on both the conservation problems in Part I and the phenomenal-real discrimination problems in Part III.

PART IV

The aim of Part IV of the thesis was to develop and test a rationale developed by the author for training nonconservers in conservation. Two major emphases in the rationale were on focusing the attention of the treatment subjects (20) on purely quantitative transformations and secondly having the subjects ignore misleading perceptual cues. With regard to the first emphasis, purely quantitative transformations were interpreted to the subjects in terms of an identity criterion (nothing added and nothing subtracted equals the same amount otherwise there will be a change in quantity). In terms of the second emphasis (see Chapter IV, Part IV, Procedure), subjects were trained to ignore misleading perceptual cues (possibly present in conservation tasks) through the use of stimuli possessing vivid phenomenal-real discrepancies. Both of the above emphases were stressed simultaneously by means of using phenomenal-real discrimination as an orienting basis for conservation acquisition. It was felt by the author that the latter procedure would satisfy admirably well two requirements deemed necessary in the training session. The first requirement was that the experimenter could effectively and meaningfully communicate to the subject what he meant by purely quantitative transformations and misleading perceptual cues. Since phenomenal-real discrimination acknowledged a distinction between two categories, and since all of the treatment and control subjects possessed phenomenal-real discrimination (as measured in Part III of the thesis), it was felt

that the subjects could be effectively made to associate all misleading cues (including non-illusory ones since they occurred in conservation tasks) under the "phenomenal" category of phenomenal-real discrimination and that purely quantitative transformations could be associated under the "real" category of phenomenal-real discrimination when the "real" was stressed with the identity criterion. The second requirement that phenomenal-real discrimination was expected to fulfill was to provide an effective means of focusing the subject throughout the various phases of the training session on the relevant aspects of a situation (nature of the transformations carried out on the objects) and having her disregard the irrelevant aspects (the misleading perceptual cues inherent in the objects). The author considered the experiments by Braine and Shanks (1965) and Murray (1966) in which a possible meaningful relationship between conservation and phenomenal-real discrimination was proposed. From the findings of Part III of the thesis, the author had to conclude that although still meaningfully related, conservation and phenomenal-real discrimination were not acquired simultaneously. As a result of emphasizing a further factor in the training session (the allowance of optimal flexibility in communication and feedback between the experimenter and the subject) the author considered some of the points stressed by Kohnstamm (Ojemann and Pritchett, 1966).

> "Our learning method was a very flexible combination of training sub-operations (e.g. counting and comparing counted numbers), making him use verbal rules to resist the misleading perceptual cues inherent in the problems, making his solution more stable and flexible by helping him through many different settings of the same problem, while at the same time discussing matters verbally with him and giving positive and negative

> reinforcements at that. Although sloppy from a methodological point of view, when we adapted strategies to the special needs of the individual child and repeated items when necessary, our five-year-olds learned to behave in a way definitely better than five-year-olds should behave according to Piagetian standards."
>
> (Ojemann and Pritchett, 1966, p. 65)

It was felt that the most effective way to conduct the training procedure was to have the experimenter guide the subject in his learning (Ojemann and Pritchett, 1966) by first communicating the problem to the subject (with the creation of evidence dissonant with his previously held convictions), then arriving with the subject at an acceptable resolution of the problem so that the necessity of the solution was realized.

> "Actually, Socrates has forced the slave-boy, little by little, to accept a conception. By repeatedly confronting the boy with evidence dissonant with his previously-accepted conceptions, Socrates forces him to develop--perhaps even to create--a new concept."
>
> (Ojemann and Pritchett, 1966, p. 119)

In a guided learning situation the subject could be made to compare and resolve the various contradictory conclusions he may possess about the conservation problem. It is not enough, in the experimenter's opinion, to suppose that when a correct rule or association is learned in a training session that the child will automatically discard conceptions which are contradictory or inconsistent with such a rule. This is precisely why training experiments designed to make the subject aware of the misleading aspects of perceptual cues or studies where the particular type of transformation is emphasized are largely unsuccessful in instilling the subjects with a clear conception of conservation. In such studies only part of the

problems associated with the nonconserver and conservation are being solved. If intervention studies are to be of any real value they must convey to the subjects concerned a full fledged concept of conservation. Otherwise it would be just as well to leave the development of conservation to a naturalistic process as Piaget has maintained (1960) where within the period of a few months or a couple of years conservation acquisition would be complete.

The emphasis placed on an identity criterion and the concern over focusing the subjects on what was considered to be relevant and and irrelevant aspects of the conservation problem were arrived at by the author as a result of his disagreement with the Piagetian position on conservation acquisition.

As a result of testing subjects (both in Part I of the thesis and in the pilot studies) on conservation tasks the author consistently made the same observation about the nonconserving subjects as Piaget (1960). The nonconserver, on being asked if anything was added or subtracted in the conservation task would always answer spontaneously (as would the conserver) that nothing in fact was added or taken away by the experimenter. The interpretation of this observation by Piaget (1960) could not be accepted by the author. Piaget argued that the above observation was evidence in support of his contention that the nonconservers did not possess an identity concept as described in the grouping. He further argued against E. Meyerson that identification was not a primary process but rather the result of an assimilation by the whole grouping (the product of the original operation multiplied by its converse), (Piaget, 1960, p. 140). Further clarification of

Piaget's position on the development of identity was given in 1968 (Piaget, J. On the Development of Memory and Identity, Clark University Press, 1968). In that discussion Piaget maintained that the non-conserver differed from the conserver in that the former possessed a concept of qualitative identity and the latter possessed a concept of quantitative identity (as a result of incorporation of identity into the grouping). The development of qualitative identity originated with the establishment of the "permanent object" in the late stages of the sensori-motor period and refinements of this concept of qualitative identity occurred up to the period of late preoperational thought.

> "Preoperational qualitative identities can very well exist in situations where there is no sign of any of the fundamental rules of operations, such as reversibility and transitivity."
>
> (Piaget, 1968, p. 21)
>
> "However, well before it becomes operational, identity is already a logical instrument."
>
> "but which lacks the inverse orientation, or in other words, reversibility."
>
> (Piaget, 1968, p. 22)
>
> "The child thinks that in changing its form, the wire changes its length:
>
> (Piaget, 1968, p. 27)

Piaget then criticizes Bruner (1966) for confusing conservation as being simple qualitative identities instead of a concept about quantity.

> "Identity does not disappear with the onset of operations, but it is integrated into structures which go far beyond it, and which encompass it as one operation among many."
>
> (Piaget, 1968, p. 35)

> "What has happened to give identity this power which it did not have before? The point is that this is no longer the same identity. The qualitative identity "it's the same water" does not lead to the same thing at all. But the notion of "nothing added" is the quantitative and operational identity "+0", and the notion of "nothing taken away" is the quantitative and operational identity "-0". The composition "+0-0=0" is the "identity operation" of an operational grouping, and this operation can only take form in conjunction with the other operations, and as a part of their total system (the additive system, etc.). It is in this sense that we believe that the structure of a "grouping" of operations as such has profound psychological meaning, and not only a logical one."
>
> (Piaget, 1968, p. 36-37).

The author agrees with Piaget with respect to the development of identity on the following points:

1. Qualitative identity begins to develop as early as the establishment of "object permanence" during the sensori-motor stage.
2. Conservation is concerned with quantitative concepts (identity) not qualitative ones.

The author disagrees with Piaget in terms of the following points:

1. The nonconserver's concept of identity does not presuppose an absence of conservation due to identity not being incorporated into a grouping.
2. Conservation can be acquired in terms of a logical inference not requiring a grouping structure.

With respect to the first point (1), the author believes the nonconserver fails to demonstrate conservation due to the possession

of ambiguous associations between states and changes in states that are perceptual and states and changes in states that are quantitative. With respect to the second point, conservation can be attained with a refinement in discrimination between the associations mentioned above. The latter point raises the possibility that either the concept of conservation is not as important as supposed by Piaget (since the grouping structure, if it exists, is not involved with conservation) or that the study of the development of the groupings should be concerned with other types of concepts.

The author considers the nature of the ambiguous associations in the nonconserver as follows:

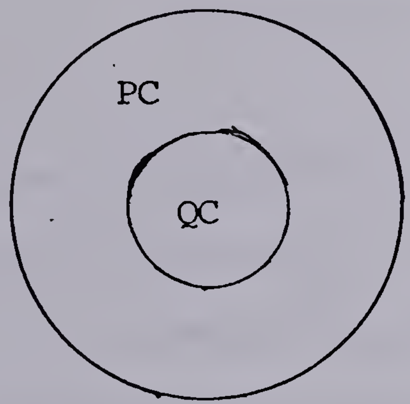
1. No ambiguity exists for either the conserver or nonconserver in understanding that for concrete objects
   a. lack of perceptual change implies lack of quantitative change ($\overline{PC} \supset \overline{QC}$).
   b. lack of quantitative change implies lack of perceptual change ($\overline{QC} \supset \overline{PC}$).
2. Ambiguity exists in the following relationships of
   a. quantitative change implies perceptual change

      $$(QC \supset PC)$$

      but perceptual change does not necessarily imply quantitative change ($PC \not\supset QC$).

The nonconserver does not appreciate the fact that perceptual change does not necessarily imply quantitative change. A refinement in associations is necessary (with respect to the associations already conceived correctly) for the nonconserver to consider the conditional

aspects of the relationship--perceptual change does not necessarily imply quantitative change. The problem is one which can be represented in terms of class inclusion.




PC - perceptual change
QC - quantitative change

From the diagram it is clear that perceptual change may or may not involve quantitative change. A contributing factor to the delay in distinguishing the above relationships is that perceptual change without quantitative change assumes an absence of the actions of addition or subtraction (+,-). It is difficult for the nonconserver to focus on the relevance of "absent" transformations (requiring the use of symbolic interpretation--absence of concrete perceptual existence) especially when perceptual change is present and that associating perceptual change with quantitative change is legitimate.

It is thus necessary to convince the nonconserver of the special relevance in making the association between perceptual change and quantitative change a conditional relationship pending the presence or absence of quantitative change (transformations as a result of addition or subtraction of quantity) regardless of the accompanying perceptual change that may be present. A procedure considered to meet the above requirements was attempted in Part IV of the research. The author does not see that success with the above procedure (in training for conservation) necessarily implies that subjects have

acquired the grouping (see Berlyne, 1965; Meyerson, 1962).

> "The principle of identity is the true essence of logic."
>
> "reversibility does not imply identity"
>
> (Meyerson, 1962, p. 216).

The training procedure was designed in the hope that the nonconservers would acquire a refinement in their discrimination between certain associations which ordinarily occurs 'naturally' as a result of unplanned but (in our culture) inevitable experience with quantitative relationships, whether deliberate instruction is given or not.

# CHAPTER IV

## RESEARCH

### Part I

Sample I

A sample of 75 subjects who gave consistent responses to particular conservation pretests (either all pass or all fail) was drawn from 10 classrooms of the Edmonton Public School System. The subjects were all female and formed three age groups of 25 subjects each (78-89 months; 90-101 months; 102-113 months). The sample size was the result of eliminating from a group of 100 subjects all of the partial conservers and secondly removing randomly from each age group as many subjects as necessary for the establishment of equally sized groups. Measures of IQ and socio-economic status were obtained from school records (tabulated a few weeks before sample selection) which provided scores on the Detroit Beginners Intelligence Test and the Blishen Occupational Class Scale, respectively.

To control for effects from order of task presentation between conservation and stage C items (see part I--procedure) the original sample was divided randomly into two equal groups which received the sets of conservation and stage C tasks in alternate orders. After the partial conservers and subjects causing unequal group size were eliminated, the two groups were compared on age, IQ, Conservation status and socio-economic rating.

The analysis of the age and conservation status groups in terms of their independent variables was carried out in Chapter IV, Data Analysis.

Apparatus I

The materials consisted of:

1. two strips of black cardboard (.5cm. x 10cm.)
2. two strips of black cardboard (.5cm. x 15cm.)
3. two square pieces of black cardboard (10cm. x 10cm.) and a pair of scissors.
4. two square pieces of black cardboard (15cm. x 15cm) and a pair of scissors.
5. two balls of plasticine (7cm. in diameter and yellow in color).
6. two balls of plasticine (5cm. in diameter and red in color).
7. two clear plastic containers of equal volume (12cm. high and 6cm. in diameter), and one clear plastic container (10cm. in diameter x 4cm. high)
8. four clear glasses (two 10cm. high and the other two both 5cm. high, all four glasses with equal diameters).

Procedure I

Prior to being presented with the conservation and stage C tasks the subjects were checked for their understanding of the terms "more", "less", "longer", "shorter", "same", and "as much as". Concrete objects differing in length, area, and mass were presented to the subjects along with questions using the above relational terms. The objects did not resemble those used in the conservation and stage

C tasks. Each of the subjects had no difficulty in understanding the questions and solving them correctly. Since the order of presentation could affect responses to the conservation and stage C tasks the sample was divided into two equal groups and each group received the conservation and stage C tasks in alternate order. A description of the conservation and stage C tasks occurs in Chapter III (Specific Aims and Rationale, Part I). Both the conservation and stage C tasks were involved with length, area, mass and continuous quantity of liquid. Subjects were classified as conservers and nonconservers independently for length, area, mass and continuous quantity of liquid. For each type of conservation task two similar problems were given along with an operational conservation check for each problem. To be classified as a conserver a subject had to pass four problems in all (two conservation tasks of the same type and two accompanying operational conservation tasks). A nonconserver was classified as a subject who failed all four of the above tasks. Subjects who passed some of the four tasks and failed others were eliminated from the sample. Since the latter subjects would create age groups of different sizes in the sample, additional subjects in each age group were randomly eliminated till each of the age groups contained an equal number of subjects. The procedure above was intended to accomplish the following:

1. a definite dichotomous classification for "conserver" and "nonconserver" ;
2. a valid classification for conservation status (Piaget, 1967);

3. a control for order of presentation of conservation and stage C tasks ;

4. a check on the subjects' understanding of relational terms relevant to the conservation and stage C task ;

5. a sample consisting of three age groups of equal size.

The conservation tasks (length, area, mass and continuous quantity) were presented in random order for each subject. The stage C tasks, whether presented before or after the conservation tasks, were also presented in random order. Although it was necessary for the objects in the conservation and stage C tasks to be highly similar in their dimensions and relative positions the objects in the conservation tasks did differ from those in the stage C tasks by being of a different color.

Questions

The questions asked in each conservation task were as follows:

1. Length

"Is one strip as long as the other strip or is one strip longer than the other?" "Why?" (Experimenter indicated each strip).

2. Area

"Is there as much black here as there is here, or is there more black in one place?" "Why?" (experimenter indicated each area).

3. Mass

"Is there as much plasticine here as there is here or is there more plasticine in one place?" (experimenter indicated each mass).

4. <u>Liquid</u>

"Is there as much water here as there is here or is there more water in one of the places?" (The experimenter indicated each body of liquid, for the two smaller glasses he indicated that the water in both glasses was considered to be a single unit).

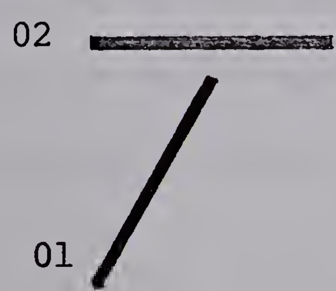
The questions asked in the stage C tasks were the same as those used for the conservation tasks except that the "WHY?" question was omitted. Also, if a subject considered that the quantity in the objects concerned was the "same", he was asked the following question:

"If one (object) had more or less, which one do you think it would probably be?" (the experimenter emphasized that the question was just hypothetical).

<u>Conservation Tasks and Operational Conservation Tasks</u>

a) Length

i) the subject was shown two equal strips of black cardboard in a juxtaposed position and his confirmation about the equality of their respective lengths was secured. The bottom strip was then changed in position so the two strips appeared as below:



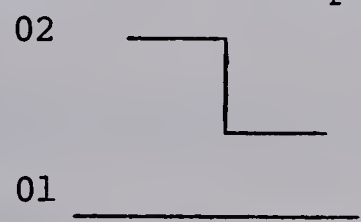

The subject was then asked about the equality of the two strips in terms of their lengths.

The operational conservation check was carried out on the two

strips above by the following questions:

"Would an ant have to walk just as far on this strip as this one (the experimenter indicated the two strips), or would it have further to walk on one of the strips?" "Why?"

ii) The subject was shown two equal strips of black cardboard in a juxtaposed position and his confirmation about the equality of their respective lengths was obtained.
The top strip was then cut into three pieces by the experimenter which were positioned to form a step as illustrated below:



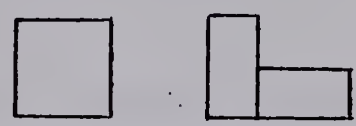

The subject was then asked about the equality of the two strips (step and straight strip) in terms of their lengths (the step was indicated by the experimenter in terms of the total length of the three segments).
The operational conservation check involved the following questions:

"If the crooked line and the straight line were sidewalks, would there be as far to walk on one sidewalk as the other one, or would there be farther to walk on one of the sidewalks?" "Why?"

b) <u>Area</u>

i) The subject was shown two black cardboard pieces of equal area. One of the pieces was placed directly on top

of the other and the subject's confirmation about the equality of size between the two pieces was obtained. The experimenter then cut one of the pieces in half with a pair of scissors and the two halves were joined to form an L shape as illustrated below:



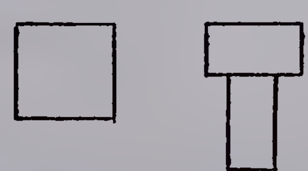
01 02

The subject was then questioned about the equality of the two black figures in terms of their respective amounts of black.

The operational conservation check involved the following questions:

"If you were to color these cards red, would there be as much to color here as there would be to color here?" "Why?" (the experimenter indicated the two figures with the L shaped figure as one area).

ii) The subject was shown two black cardboard pieces of equal area. One of the pieces was placed directly on top of the other and the subject's confirmation about the equality between the two pieces was obtained. The experimenter then cut one of the pieces in half with a pair of scissors and the two halves were joined to form a T shape as illustrated below:



01 02

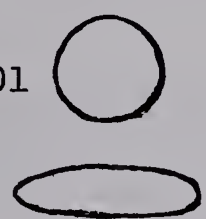
The subject was then questioned about the equality of the two black figures in terms of their respective amounts of black.

The operational conservation check involved the following questions:

"If these were two patches of grass, would a cow have as much to eat on one patch as the other patch?" "Why?" (the experimenter referred to the T figure as one area).

c) <u>Mass</u>

i) The subject was shown two balls of plasticine (equal in mass) and his confirmation about their quantitative equivalence was obtained. One of the balls of plasticine was rolled into a sausage shape and placed next to the other ball as illustrated below:



01

02

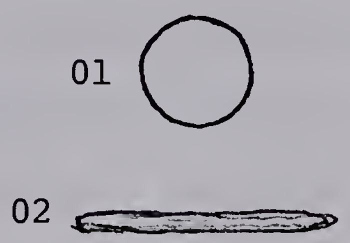
The subject was then questioned about the equality of the two pieces of plasticine in terms of their quantity.

The operational conservation check involved the following questions:

"If the two pieces of plasticine were bread, would you have as much bread to eat here as you would have here?" "Why?" (the experimenter pointed to the two pieces of plasticine).

ii) The subject was shown two balls of plasticine

(equal in mass) and his confirmation about their quantitative equavalence was obtained. One of the balls of plasticine was flattened into a pancake and placed next to the other ball as illustrated below:



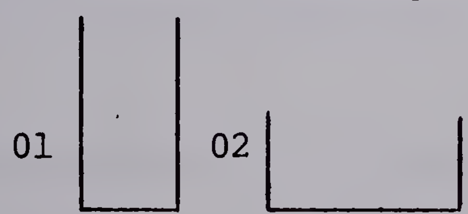

The subject was then questioned about the equality of the two pieces of plasticine in terms of their quantity.

The operational conservation check involved the following questions:

"If the two pieces of plasticine were chocolate, would you have as much chocolate to eat with one piece as with the other piece?" "Why?"

d) <u>Liquid</u>

i) The subject was shown two identical glasses filled to the same level with water and his confirmation about the equality of water in the two glasses was obtained. The water from one of the glasses was poured into a container that was shorter and wider than the other two glasses and the container was placed beside the filled glass as illustrated below:




The subject was then questioned about the equality of the water in the two receptacles in terms of its quantity.

The operational conservation check involved the following task:

After the receptacles containing the water were removed, two different glasses were placed in front of the subject and he was asked to try and pour the same amount of water into both of the glasses (one tall and thin, the other short and wide).

ii) The subject was shown two identical glasses filled to the same level with water and his confirmation about the equality of water in the two glasses was obtained. The water from one of the glasses was poured into two small glasses (both shorter than the original two glasses and both identical to each other). The two small glasses were placed next to the remaining filled tall glass as illustrated below:


The subject was then questioned about the equality of the water in the tall glass with the water in both of the small glasses in terms of quantity (the experimenter indicated that the water in both of the small glasses was considered as one unit).

The operational conservation check involved the following questions:

"If a man was to drink the water, would he have as much to drink in the tall glass (indicated by the experimenter)

as he would have in both of the smaller glasses (indicated by the experimenter as one unit)?" "Why?"

For all of the conservation tasks, nonconservers were asked to indicate which object they considered to have "more" quantity and which object to have "less" quantity.

Stage C Tasks

The same questions were asked on the stage C tasks as were asked on the conservation tasks except that no "why" questions followed. The objects used for comparison were similar in dimensions and relative positions to those used in the conservation tasks (objects in the conservation tasks after one of the objects for a particular task was transformed). The stage C tasks therefore consisted of two tasks for each comparison of length, area, mass and liquid quantity. For each task the subject was shown two particular objects (involving a question about their respective lengths, areas, masses or liquid quantities). If he maintained that they were equal in quantity he was scored for his response (1 = no discrepancy) and then asked a second question involving the hypothetical consideration of quantitative inequality between the objects (see Procedure, Part I--questions). The subject's choice of object (as having "more" or "less") was recorded. If a subject stated that the objects were unequal (in quantity) as an initial answer, his choice of object was recorded and he proceeded to the next task.

After all of the subjects had been tested on the conservation and stage C tasks they were given in random order tasks involving

length, area, mass and liquid quantity where there was actual addition or subtraction of quantity from one of the objects for a particular task. It was felt that if these tasks were interspersed with the former conservation and stage C tasks undesirable distractions would result in confounding the comparison of responses between the conservation and stage C tasks. It should be remembered that only nonquantitative transformations occurred in the conservation tasks and that the comparison of responses on the conservation and stage C tasks was concerned with investigating the role of the state attributes (perceptual features) of the objects and the nonquantitative transformations associated with such attributes in affecting the answer of the nonconserver.

Hypotheses I

$H_1$ - The order of presentation of the conservation and stage C tasks will not affect significantly the nature of the responses (number of pass and fail) to these tasks.

$H_2$ - The groups of subjects who pass particular conservation tasks will not, on the corresponding stage C tasks, choose one object significantly more times than the other object (as possessing more quantity).

$H_3$ - The groups of subjects who fail particular conservation tasks will, on the corresponding stage C tasks, choose one object significantly more times than the other object (as possessing more quantity).

$H_4$ - On the stage C tasks, quantitative equality will be acknowledged significantly more times by the conservers than by the nonconservers.

$H_5$ - Nonconservers will tend to consider the same object (as possessing more quantity) in the conservation tasks as in the stage C tasks.

## Data Analysis I

After the elimination of the partial conservers and the size equalization of the age groups, the sample (75 subjects) was analyzed (in terms of age and conservation status groups) on the independent variables of age, IQ and socio-economic status. The following table shows the means and variances associated with the variables of age, IQ and socio-economic status for each of the groups. Although the Hartley and Fmax statistic (Winer, 1962, p. 98) was used to test for homogeneity of variance, it is not reported since none of the tests lead to a rejection of the Mill hypothesis.

The number of conservers and nonconservers for each age group were compared using a chi square for two independent samples (incorporating a correction for continuity). The comparison of age groups on the number of conservers and nonconservers in each group is given in Table II.

TABLE I

MEANS AND VARIANCES FOR AGE AND CONSERVATION STATUS GROUPS

| | AGE | | IQ | | BLISHEN SCALE | |
|---|---|---|---|---|---|---|
| | mean | variance | mean | variance | mean | variance |
| Age Group I N = 25 | 84.36 | 18.74 | 101.32 | 65.73 | 50.44 | 62.11 |
| Age Group 2 N = 25 | 96.64 | 15.66 | 103.04 | 61.04 | 49.41 | 63.06 |
| Age Group 3 N = 25 | 107.76 | 13.86 | 100.48 | 89.60 | 48.82 | 61.53 |
| Conservers N = 35 | 101.74 | 70.39 | 101.74 | 76.57 | 50.51 | 72.76 |
| Nonconservers N = 40 | 91.45 | 89.11 | 101.85 | 62.25 | 48.72 | 47.75 |
| Combined Age Groups N = 75 | 96.25 | 106.78 | 101.61 | 70.37 | 49.56 | 60.20 |

(CONSERVATION STATUS GROUPS BASED ON LENGTH CONSERVATION TASKS ONLY)

TABLE II

COMPARISON OF AGE GROUPS ON CONSERVATION STATUS

| | C | NC | | $X^2$ | P |
|---|---|---|---|---|---|
| A1 | 6 | 19 | 25 | 1.43 | - |
| A2 | 11 | 14 | 25 | | |
| | 17 | 33 | 50 | | |
| | C | NC | | | |
| A2 | 11 | 14 | 25 | 2.96 | - |
| A3 | 18 | 7 | 25 | | |
| | 29 | 21 | 50 | | |
| | C | NC | | | |
| A1 | 6 | 19 | 25 | 9.70 | ** |
| A3 | 18 | 7 | 25 | | |
| | 24 | 26 | 50 | | |

C - conservers
NC - nonconservers
A - age group
** - significance at the .01 level

The results indicated that the oldest age group contained significantly more conservers than the youngest age group.

A one-way analysis of variance was used to compare age groups on IQ and socio-economic status. The results indicated no significant differences as illustrated in Table III.

TABLE III

ANALYSIS OF VARIANCE: I(IQ) - II(SOCIO-ECONOMIC STATUS)

| | SOURCE | SS | MS | DF | F | P |
|---|---|---|---|---|---|---|
| I. | | | | | | |
| | Groups | 85.19 | 42.59 | 2 | 0.59 | 0.56 |
| | Error | 51.93 | 72.12 | 72 | | |
| II. | | | | | | |
| | Groups | 33.44 | 16.72 | 2 | 0.27 | 0.76 |
| | Error | 4481.28 | 62.24 | 72 | | |

Conservation status groups were also compared on IQ and socio-economic status by the use of t tests as shown below. The results indicated no significant differences.

TABLE IV

COMPARISON OF CONSERVATION STATUS GROUPS ON IQ AND SOCIO-ECONOMIC STATUS

| VARIABLE | DF | T | P-two tail |
|---|---|---|---|
| IQ | 73 | .258 | .80 |
| SOCIO-ECONOMIC STATUS | 73 | .985 | .33 |

The order groups (1/2 of the sample receiving the conservation tasks before the stage C tasks and 1/2 of the sample receiving the tasks in the alternate order) were compared for differences on age, IQ and socio-economic status using t tests and the results are

illustrated below.

TABLE V

ORDER GROUP COMPARISON ON AGE, IQ AND SOCIO-ECONOMIC STATUS

| VARIABLE | DF | T | P-two tail |
|---|---|---|---|
| AGE | 72 | .45 | .68 |
| IQ | 72 | .25 | .81 |
| SOCIO-ECONOMIC STATUS | 72 | 1.5 | .14 |

The order groups did not differ on any of the three variables. A chi square for two independent samples was also nonsignificant in comparing the order groups on their respective numbers of conservers and nonconservers.

Hypothesis I

To test hypothesis I a chi square for two independent samples incorporating a correction for continuity (Siegel, 1956, p. 107) and the Fisher Exact Z statistic (Siegel, 1956, p. 96) were used. It was necessary to use the Fisher test on some of the comparisons because particular expected frequencies fell below 5. Since in addition some of the groups did not exceed a size of 15, the tables adapted by Finney (Siegel, 1956, p. 256) could be used. Hypothesis I was tested by comparing the order groups on each conservation task and each stage C task. The tasks were analyzed in terms of "pass" and "fail" responses as well as in terms of object choice. The latter analysis involved a comparison of the number of choices (per group) for each object of a particular conservation or stage C task. A choice was

considered as a selection of an object on the basis that (for the subject) it contained more quantity than the other object.

The results illustrated below indicate that no differences existed in responses to conservation and stage C tasks due to their order of presentation.

TABLE VI

COMPARISON OF ORDER GROUPS ON THE CONSERVATION AND STAGE C TASKS

| | L1 | L2 | A1 | A2 | M1 | M2 | Q1 | Q2 |
|---|---|---|---|---|---|---|---|---|
| CONSERVATION TASKS (pass-fail) | -- | -- | -- | -- | -- | -- | -- | -- |
| STAGE C TASKS (Pass-fail) | -- | -- | -- | -- | -- | -- | -- | -- |
| CONSERVATION TASKS (choice) | -- | -- | -- | -- | -- | -- | -- | -- |
| STAGE C TASKS (choice) | -- | -- | -- | -- | -- | -- | -- | -- |
| STAGE C TASK (forced choice) | -- | -- | -- | -- | -- | -- | -- | -- |

Chi Square .05 = 3.84
.01 = 6.64

-- - probability greater than .05
L - length
A - area
M - mass
Q - liquid

Hypothesis 2

To test hypothesis 2 a binomial test was used since some of the expected frequencies were five or less. The results indicated that the hypothesis held up for 6 out of 8 tasks. A task involving liquid quantity and one involving length produced results which were significant at the .05 levels indicating that the tall narrow glass and the straight strip of cardboard were considered to have more quantity than their respective counterparts (short wide container and bent strip of cardboard in the zig zag position). The results pertaining to hypothesis 2 are given in Table VII.

TABLE VII

CONSERVERS CHOICE RESPONSES ON THE STAGE C TASKS

| | L1 | L2 | A1 | A2 | M1 | M2 | Q1 | Q2 |
|---|---|---|---|---|---|---|---|---|
| (i) | 6 | 2 | 8 | 8 | 9 | 9 | 10 | 7 |
| (ii) | 4 | 12 | 11 | 10 | 11 | 12 | 2 | 1 |
| N | 10 | 14 | 19 | 18 | 20 | 21 | 12 | 8 |
| P | .754 | .012 | .648 | .808 | .824 | .664 | .038 | .070 |
| .05 | - | * | - | - | - | - | * | - |
| .01 | - | - | - | - | - | - | - | - |

L - length task
A - Area task
M - Mass task
Q - liquid task

N - number of subjects
P - probability associated with the binomial
(i) - number of subjects choosing object 1
(ii) - number of subjects choosing object 2

Hypothesis 3

To test hypothesis 3 a chi square (goodness of fit for two categories, P = .5) was used. The results indicated that the hypothesis held up for the tasks involving length and liquid quantity but that on the four tasks involving area and mass no biased selection was made. A comparison of the results used to test hypotheses 2 and 3 indicated that conservers and nonconservers performed in a similar manner on the stage C tasks (only for subjects making a choice of object). The results for hypothesis 3 are given below.

TABLE VIII

NONCONSERVERS CHOICE RESPONSES ON THE STAGE C TASKS

| | L1 | L2 | A1 | A2 | M1 | M2 | Q1 | Q2 |
|---|---|---|---|---|---|---|---|---|
| (i) | 21 | 1 | 15 | 19 | 17 | 18 | 29 | 32 |
| (ii) | 5 | 29 | 17 | 15 | 13 | 13 | 4 | 6 |
| N | 26 | 30 | 32 | 34 | 30 | 31 | 33 | 38 |
| $X^2$ | 9.85 | 26.13 | .13 | .47 | .53 | .81 | 18.94 | 17.79 |
| .05 | * | * | - | - | - | - | * | * |
| .01 | ** | ** | - | - | - | - | ** | ** |

L - length task
A - Area task
M - Mass task
Q - liquid task

N - Number of subjects
$X^2$ - value of chi square
(i) - number of subjects choosing object 1
(ii) - number of subjects choosing object 2

TABLE IX

COMPARISON OF CONSERVERS AND NONCONSERVERS ON THE STAGE C TASKS

| | L1 | | L2 | | A1 | | A2 | | M1 | | M2 | | Q1 | | Q2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 01 | 02 | 01 | 02 | 01 | 02 | 01 | 02 | 01 | 02 | 01 | 02 | 01 | 02 |
| NC | 12 | 3 | 15 | 0 | 7 | 8 | 9 | 6 | 9 | 6 | 9 | 6 | 14 | 1 | 13 | 2 |
| C | 6 | 4 | 12 | 2 | 6 | 9 | 7 | 8 | 7 | 8 | 6 | 9 | 10 | 2 | 7 | 1 |
| .05 | - | | - | | - | | - | | - | | - | | - | | - | |
| .01 | - | | - | | - | | - | | - | | - | | - | | - | |

L - length task

A - area task

M - mass task

L - liquid task

C - Conserver

NC - Nonconserver

01 - Object 1 chosen as more

02 - Object 2 chosen as more

* - significance at the .05 level for chi square

** - significance at the .01 level for chi square

To compare for differences in choice responses on the stage C tasks between the conservers and nonconservers a Fisher Exact Z statistic was used since some of the expected frequencies were less than five. To allow for the use of the Finny tables (Siegel, 1956, p. 256) subjects for the comparison were chosen randomly not in excess of fifteen for each group. The results are indicated in Table IX.

To provide further information about the nonconserver's responses (choice of object that is considered to have more quantity) the nonconservers were analyzed for their choice of object on the conservation tasks. The results given in Table X were analyzed by means of a chi square test (goodness of fit for two categories with P = .5). On all of the Conservation tasks one object was chosen more than the other (with respect to possessing more quantity).

TABLE X

NONCONSERVERS CHOICE RESPONSES ON THE CONSERVATION TASKS

| | L1 | L2 | A1 | A2 | M1 | M2 | Q1 | Q2 |
|---|---|---|---|---|---|---|---|---|
| (i) | 37 | 37 | 32 | 33 | 10 | 10 | 44 | 44 |
| (ii) | 3 | 3 | 8 | 7 | 26 | 26 | 0 | 0 |
| N | 40 | 40 | 40 | 40 | 36 | 36 | 44 | 44 |
| $X^2$ | 28.9 | 28.9 | 14.4 | 16.9 | 7.1 | 7.1 | 44.0 | 44.0 |
| .01 | ** | ** | ** | ** | ** | ** | ** | ** |

L - Length task
A - area task
M - mass task
Q - liquid task

N - number of subjects
$X^2$ - value of chi square (goodness of fit)
(i) - number of subjects choosing object 1
(ii) - number of subjects choosing object 2

Hypothesis 4

Hypothesis 4 was tested by means of a chi square test for two independent samples (incorporating a correction for continuity, Siegel, 1956, p. 107). The results given in Table XI indicate that except for one of the tasks involved with Mass, the nonconservers made significantly more choice responses than did the conservers. The conservers tended to consider both objects as possessing equal quantity (stage C task).

Hypothesis 5

To test hypothesis 5 a chi square (goodness of fit for two categories with the expected frequency for each category equal to one half). Subjects choosing the same object (as having more quantity) on a particular conservation task and the corresponding stage C task were compared with subjects who chose a different object. A significant chi square (considered at both the .05 and .01 levels) supported the hypothesis. The results indicated in Table XII show that the hypothesis was supported at the .01 level for all of the tasks concerned with length and liquid quantity and at the .05 level for one of the tasks concerned with mass (ball and pancake) and one of the tasks concerned with area (square and T figure).

The responses of the nonconservers who chose a different object on a particular conservation task from the object on the corresponding stage C task were further analyzed for differences in the direction of change with a binomial test (the McNemar test was not used because of the small expected frequencies). The results

TABLE XI

COMPARISON OF CONSERVATION STATUS GROUPS ON STAGE C TASKS CHOICE SUSCEPTIBILITY

| | L1 | | L2 | | A1 | | A2 | | M1 | | M2 | | Q1 | | Q2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - |
| C | 24 | 11 | 19 | 16 | 18 | 19 | 21 | 16 | 15 | 24 | 19 | 19 | 20 | 11 | 21 | 10 |
| NC | 14 | 26 | 10 | 30 | 6 | 32 | 4 | 34 | 6 | 30 | 5 | 32 | 11 | 33 | 6 | 38 |
| $X^2$ | 7.05 | | 5.51 | | 9.17 | | 17.79 | | 3.56 | | 11.57 | | 11.56 | | 20.57 | |
| .05 | * | | * | | * | | * | | - | | * | | * | | * | |
| .01 | ** | | - | | ** | | ** | | - | | ** | | ** | | ** | |

L - length task

A - area task

M - mass task

Q - liquid task

C - conservers

NC - nonconservers

\+ - subjects not making a choice between objects

\- - subjects making a choice between objects

TABLE XII

NONCONSERVERS OBJECT CHOICE ON THE CONSERVATION AND STAGE C TASKS

| | L1 | L2 | A1 | A2 |
|---|---|---|---|---|
| + | 22 | 29 | 21 | 24 |
| - | 4 | 1 | 11 | 10 |
| $X^2$ = | 12.46 | 27.32 | 3.12 | 5.80 |
| .05 | * | * | - | * |
| .01 | ** | ** | - | - |

| | M1 | M2 | Q1 | Q2 |
|---|---|---|---|---|
| + | 19 | 21 | 29 | 32 |
| - | 11 | 10 | 4 | 6 |
| $X^2$ = | 2.14 | 3.90 | 18.94 | 17.78 |
| .05 | - | * | * | * |
| .01 | - | - | ** | ** |

L - length task

A - area task

M - mass task

Q - liquid task

\+ subjects choosing same object

\- subjects choosing different objects

TABLE XIII

COMPARISON OF NONCONSERVERS ON DIRECTION OF OBJECT CHOICE

**L1**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 4 | 21 |
| 02 | 1 | 0 |

P = .070
.05 -
.01 -

**L2**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 1 | 29 |
| 02 | 0 | 0 |

P = .500
.05 -
.01 -

**A1**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 10 | 15 |
| 02 | 6 | 1 |

P = .11
.05 *
.01 -

**A2**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 10 | 19 |
| 02 | 5 | 0 |

P = .001
.05 *
.01 **

**M1**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 1 | 7 |
| 02 | 12 | 10 |

P = .011
.05 *
.01 -

**M2**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 0 | 8 |
| 02 | 13 | 10 |

P = .001
.05 *
.01 **

**Q1**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 4 | 29 |
| 02 | 0 | 0 |

P = .070
.05 -
.01 -

**Q2**

Stage C task

| Conservation task | 02 | 01 |
|---|---|---|
| 01 | 6 | 32 |
| 02 | 0 | 0 |

P = .016
.05 *
.01 -

L - length task
A - area task
M - mass task
Q - liquid task

01 - subjects choosing object 1
02 - subjects choosing object 2
P - probability associated with the binomial test

indicated that at the .05 level the direction of change (in choice of object) was significant for the area, mass and one of the liquid tasks. At the .01 level the direction of change was significant for the area and mass tasks. The results are given in Table XIII.

Reliability and Validity I

The validity of the tasks used to test for conservation status is inherent in the definition of conservation stated in Chapter I of the thesis. The questions and transformations used in the conservation tasks were in accord with the requirements necessary to test for an understanding of the principle that quantity remains invariant despite changes in other attributes. No feedback was allowed with respect to the subject's answers on the conservation or stage C tasks. To be classified as a conserver, the subject had to pass four out of four tasks for each type of conservation measured (two conservation tasks and two operational conservation checks). Although the operational conservation checks did not involve direct action on the part of the subject (except on one of the liquid tasks) in each check, action was implied in the questions. Only answers in terms of a logical criteria ([1] nothing was added or taken away, [2] reversibility - an inverse transformation could restore the initial states of the objects [3] compensation - in terms of Piaget's "equation of differences", 1960) were accepted as conservation responses. Nonconservers were classified as subjects failing the above criterion (partial conservers were eliminated from the sample). Furthermore, the verbal responses of the subjects were considered preferable to nonverbal responses in

that the understanding of the logical necessity of conservation for a particular task could be ascertained. For a valid comparison of responses to the conservation and stage C tasks a high degree of controlled similarity was necessary and such a control was incorporated in the tasks. Controls for effects from order of task presentation between the conservation and stage C tasks were carried out. Also, the sets of conservation and stage C tasks were presented to each subject in random order.

The classification of the sample in terms of conservation status was given further reliability by comparing the author's classification with that of another experimenter. Disagreement was reached on only three of the subjects and these were eliminated from the sample with the partial conservers.

Before the subjects were presented with the stage C and conservation tasks they were checked on their understanding of relational terms such as "more", "less", "same" and "longer". After the presentation of the conservation and stage C tasks the subjects were given conservation tasks where in fact actual quantity was added or subtracted in which all subjects were successful.

## Discussion I

### Hypothesis 1

No significant differences were observed on the conservation and stage C tasks as a result of order of presentation. This indicated that the results for testing hypotheses 2, 3, 4 and 5 could not be attributed to order effects of task presentation for the conservers

or nonconservers.

Hypothesis 2, 3 and 4

The results for testing hypothesis 4 indicated that the conservers were not as susceptible to phenomenal discrepancies contained by the objects used in the stage C tasks as the nonconservers. The conservers did not tend to make a choice on the stage C tasks as did the nonconservers nor were they as prone as the nonconservers in making a biased choice (one object in preference to the other) when in fact a choice was made. However, in comparing the conservers and nonconservers who made choice responses to the stage C tasks it was observed that both groups showed similar trends and that the differences were not significant (Table IX). For both of the conservation status groups responses were not always consistent from one type of task to another (length, area, mass and liquid).

Hypothesis 5

Nonconservers tended to be consistent in their choice of object on the conservation and stage C tasks for problems of length, liquid. For problems involved with mass and area only half of the tasks were consistent at the .05 level. It can be concluded that except for a problem involved with area and one with mass, the nonconservers could have made their answers in terms of the perceptual features of the objects rather than the transformation involved with the same objects. However, in further analyzing the responses of subjects who gave inconsistent choice responses on the conservation

and stage C tasks for respective problems of length, area, mass and liquid, it was found that the direction of choice change was significant for problems dealing with mass and area as well as one liquid problem. This would imply that although the majority of non-conservers could have answered the tasks in terms of the state attributes of the objects (perceptual features), the minority of subjects who did show a change of object choice between the conservation and stage C tasks were solving the conservation tasks in terms of the transformations occurring on the objects instead of the state attributes (perceptual features of shape, size).

Also for those tasks where a significant change in the direction of choice was not observed lack of transformation effects may not be as responsible as the fact that sample size was too small (subjects compared for significant changes in the direction of object choice on the length tasks, for example, were too small in size to observe trends--4 subjects for one task, one subject for the other task.

It can be concluded that nonconservers make their responses to conservation tasks in terms of both the perceptual features of the objects and the transformations being performed on the same objects. Also, for particular tasks, the transformations involved can override the phenomenal effects of the objects and cause the subject to choose an object as having more or less quantity because of the transformation performed upon it. This was obvious in the area tasks where in a mere visual comparison situation (stage C tasks) the L shaped figure was considered to have more area than the square figure but when the same objects were present in a task of area conservation

the square object was considered to have more quantity due to the reasoning that the other figure was "cut" thus making it have less quantity.

It seems appropriate to state that nonconservers in failing conservation tasks seek to justify their answers both in terms of observable perceptual features of objects as well as in the transformations performed on these objects. Thus both states and transformations are important factors to consider when the objective is to train nonconservers in conservation. It may be essential that besides aiding the nonconserver to ignore misleading perceptual cues it is just as vital to also have him develop a more sophisticated interpretation of the transformations involved in the conservation task but to accomplish the latter a mutual attack on both states and transformations may be necessary. Not until the subject has interpreted the perceptual cues (state attributes) and the transformations on the objects in a coherent noncontradictory argument can he come to the conclusion of the logical necessity of conservation in tasks designed to measure such an understanding. An attempt to develop a training procedure for conservation acquisition incorporating such criteria is discussed in part IV of the thesis.

# PART II

## Sample II

In terms of age groups, the same subjects were used as in part one of the study. Groups designated as conservers and nonconservers (for length only) were selected from the sample on the basis of matching with respect to the variable of age and this resulted in eighteen subjects being allocated to each group. Such a selection was deemed necessary since it was essential that each variable (age and conservation status) be measured independently and because in part one of the study it was shown that presence of conservation and age were positively related. All subjects possessed adequate normal vision (eye glasses removed) with respect to discriminating objects at various distances and degrees of illumination.

## Apparatus II

1. Polymetric Products Eye-Movement Recorder (Model V-1164-1) Manufactured by Polymetric Company, 1415 Park Avenue, Hoboken, New Jersey, U.S.A. 07030. (using a Pathe "Professional" 16mm. reflex movie camera to record on film corneal reflections at the constant exposure rate of 10 frames per second.)

2. Stimulus Materials - slides of a modified Muller-Lyer illusion (see figure 2 for actual dimensions) viewed at a distance of approximately 24 inches on a viewing area of 7.8 x 7.8 inches, slides of two straight parallel lines, slides of the modified Muller-Lyer

Fig. 1. Experimental Setting for the Recording of Eye Movements

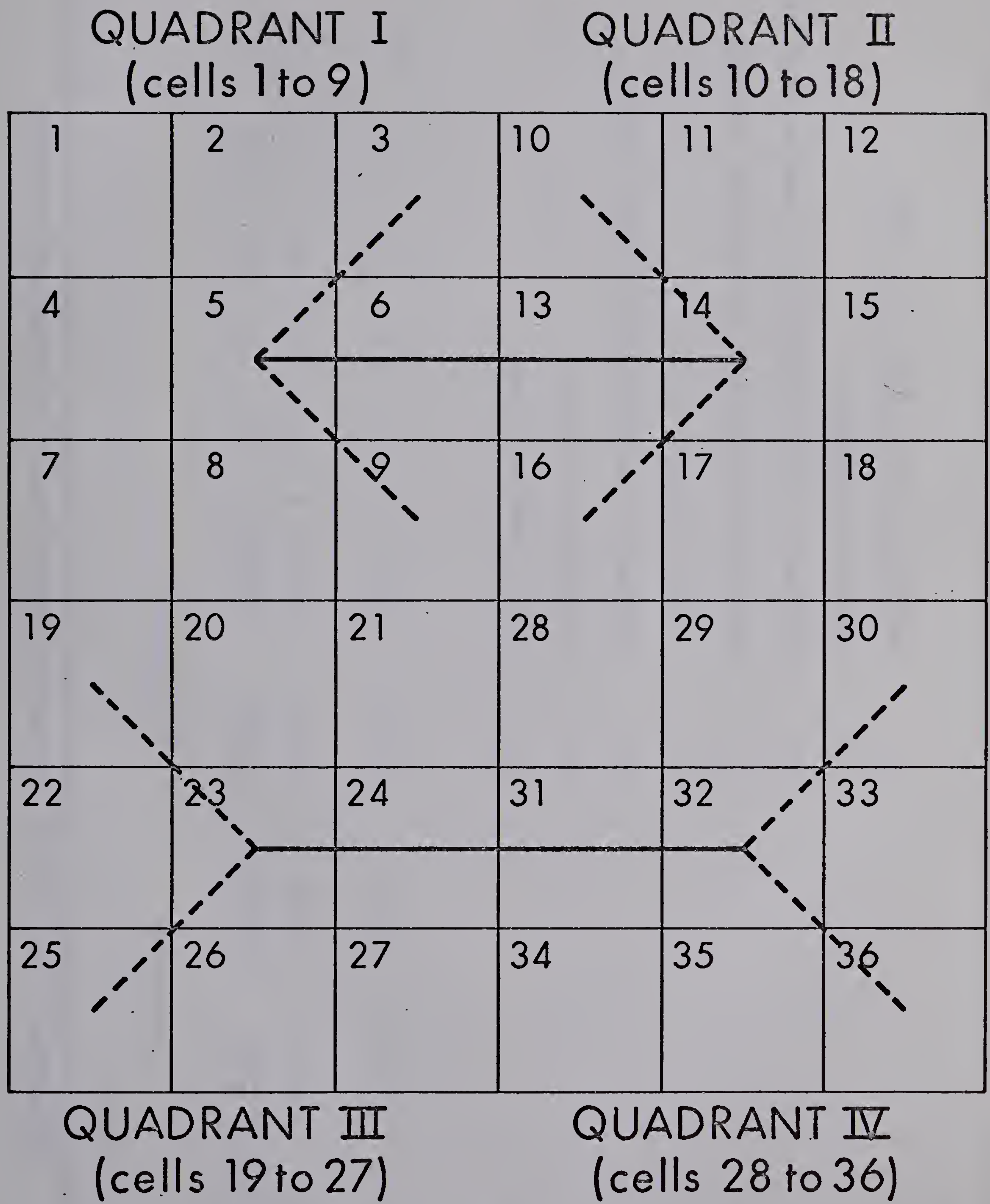



FIG. 2 MULLER-LYER ILLUSION DIVIDED INTO STIMULUS AREAS.

TABLE XIV

COMPARISON OF THE SELECTED CONSERVATION STATUS GROUPS ON INDEPENDENT VARIABLES

| | Conservers | | Nonconservers | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Mean | Variance | Mean | Variance | df1 | t | P1 | df2 | F | P2 |
| IQ | 100.72 | 67.42 | 101.61 | 52.68 | 34 | .33 | .74 | 17 | 1.28 | .15 |
| BS | 51.33 | 80.70 | 49.38 | 50.54 | 34 | .70 | .49 | 17 | 1.60 | .09 |

IQ - Detroit Beginners test

BS - Blishen Scale rating

df1 - degrees of freedom associated with t test

t - t test on means

P1 - probability associated with value of 5-2 tail

df2 - degrees of freedom associated F test on variances

F - F test on variances

P2 - probability associated with F test

illusion with one line actually longer, cards illustrating dotted and solid lines.

3. Random access slide projector--for presentation of slides (see (2) above).

4. Two tape recorders, three sets of head phones, microphones.

5. Dental equipment--for bite-bar preparation and sterilization.

6. Micro-film reader--for viewing film containing recordings of corneal reflections.

7. Laboratory room--especially designed for eye movement recording (room painted black, light intensity control, sound attenuation).

8. Playroom--used as a supervised waiting room for the subjects while testing was in progress in the laboratory room.

Procedure II

Subjects were transported to the testing room (laboratory) by taxi in groups of five at 1:00 p.m. in the afternoon over a period of several days. On arrival the playroom supervisor conducted them to the waiting room where the subjects were occupied with various toys and games.

Prior to being set up to the apparatus the subjects were instructed to close their eyes as soon as they had an answer to the experimenter's questions. The experimenter emphasized a high degree of proficiency in the performance of the above rule with several trial tasks not involved with the experiment proper. Also subjects were questioned for their understanding of relational terms such as "more",

"less", "longer", "shorter" and "same" when these terms were applied to questions about concrete objects and drawings of various lengths of lines. Each subject was individually presented to the apparatus in the laboratory and emphasis was placed on explaining the novel items so that the subjects were not afraid of the experimental setting. The experimenters maintained an informal and friendly atmosphere in the laboratory while constantly checking for signs of uneasiness on the part of the subject. Since the experimenters had several opportunities to be exposed to the subjects prior to the testing (in the schools) no difficulty was experienced in getting co-operation from the subjects (except for one subject who was excluded from the sample). Emphasis was also placed on politely answering any of the subjects' questions.

During the time that the experimenters were acclimatizing the subjects to the experimental setting the dental compounds to be used for bite-bars were being softened in a specially designed heater.

The subject was positioned in an adjustable chair and a tooth impression was made in the dental compound by the subject (dental compound in place as bite-bar). A careful check was made on the tooth impression to see if a deep enough bite was made by the subject and if such was not the case another try was made using a new piece of dental compound. This procedure was deemed essential because a poor tooth impression in the compound would increase the chances of the subject actually moving his head during the recording of the eye movements. When a good impression was attained (usually after two attempts) the bite-bar was allowed to harden (couple of minutes). During this time the subject was questioned for his discrimination

ability between solid and dotted lines as presented on white cardboard. This was necessary since the illusion stimulus contained both dotted and solid lines. The subject was also presented with slides containing dotted and solid lines on the screen where the illusion stimulus was subsequently to appear. Since the dotted and solid lines were similar on the discrimination slides to those composing the illusion stimulus a check was provided for the visibility and discrimination ability of the dotted and solid lines. None of the discrimination slides possessed sets of lines that would resemble the Muller-Lyer illusion or create a phenomenal-real discrepancy in length.

Either before or after the presentation of the discrimination slides (dotted and solid lines) the subject's eye fixations were calibrated. While the subject was positioned properly in the chair and biting on the bite-bar a beam of light was focused on the left eye. The subject was told to fixate a target (either an X or a small circle in the center of the viewing screen or a number in one of the four corners of the viewing screen) on a white card while the experimenter adjusted the co-ordinates of the camera so that the locus of the corneal reflection (from the subject's eye) on the viewing screen coincided with the position the subject was fixating (the target). If a quick calibration was not possible (less than 30 seconds) the subject was allowed to release the bite-bar and have intermittent rest periods. Time taken for calibration was generally a couple of minutes. During the calibration period the subject was given the opportunity to practice closing her eyes when she had the answer to the experimenter's questions. Subjects were also accustomed to the ear phones and a taped sequence of the experimenter's voice.

The recording of the subjects' eye movements as a result of their examination of the Muller-Lyer illusion stimulus was carried out with the following conditions present:

1. Muller-Lyer illusion stimulus (two parallel horizontal solid lines 3 inches long and each dotted wing 1 1/4 inches long, angle of wings set at 90°, the solid lines separated by 3 inches with one solid line lying horizontally directly above the other solid line).

2. The illusion was presented six times to each subject (the positions of arrow/feather and feather/arrow were presented with each of the three verbal instructions).

| Illusion Position | Verbal Instruction |
|---|---|
| 1. arrow/feather | 1. "Is one solid line as long as the other solid line?" |
| 2. arrow/feather | 2. "Is one solid line as short as the other solid line?" |
| 3. arrow/feather | 3. "Is one solid line the same as the other solid line?" |

The same verbal instructions were associated with the illusion stimulus in the other position (feather/arrow). Each of the six trials had a randomly selected position of illusion stimulus and a randomly selected verbal instruction.

3. The verbal instructions were taped and presented to the subject via ear phones (the ear phones also functioned to filter out extraneous noise from the experimenter's manipulations of the equipment). Each verbal instruction was exactly three seconds in duration and was presented at the same time as the illusion stimulus.

Such synchronization was necessary (as discussed in the section of the thesis concerned with the pilot studies) to optimize the ease of recording the eye movements. With respect to the latter point it was also essential that the verbal instructions were clear and yet as short as possible.

4. The maximum latency for each trial of stimulus presentation was 10 seconds (even if by this time subject had not closed her eyes). Only six trials from those presented for all of the subjects were terminated at the 10 second interval, all of the other trials were terminated by the subject (closing of the eyes).

5. After the subject was finished observing the stimulus he was questioned about his answer (which solid line--top or bottom was considered to be longer, shorter). Since all of the subjects maintained on all trials that the two solid lines were unequal the above question did not confound the results. Also, since the illusion stimulus was removed after the closing of the eyes, the question was effective in checking the memory of the subject and his original choice of line (as being longer or shorter).

No feedback as to the correctness or incorrectness of the subjects answer was provided.

6. After the six trials were presented to the subject four additional stimuli were given to each subject. Two of the four stimuli was an illusion stimulus similar to the one presented on the six prior trials except that the solid lines were of different lengths, (the solid line on the arrow figure was extended on both ends and the solid line on the feather was shortened at both ends so that the arrow

solid line was one half inch longer than the feather solid line). In terms of the wing positions the feather wings still extended beyond the extremities of the arrow figure. The above stimulus was presented in alternate positions similar to that of the illusion stimulus in the six prior trials (thus making up two of the additional four stimuli). For all of the four additional stimuli identical verbal instructions to those used in the original six trials were used.

The other two stimuli (of the four additional stimuli) were two parallel horizontal solid lines three inches in length and three inches apart with edges coinciding. The four additional stimuli were to serve as controls (see Reliability and Validity, Part II) for the illusion stimulus presented on the six original trials for each subject. Half of the sample received the four additional stimuli on the same viewing screen as the original illusion stimulus and half of the sample received them at a desk presentation. The order of presentation of the four stimuli was randomized. Eye movement data was not considered for the four additional stimuli (see Reliability and Validity, Part II).

Hypotheses II

$H_1$ - The latency of scanning will not vary significantly over the type of position of the illusion stimulus or the type of verbal instruction for any of the groups (age and conservation status).

$H_2$ - The latency of scanning will vary significantly over the number of trials of stimulus presentation for all groups (age and conservation status).

$H_3$ - The latency of scanning will not vary significantly over trials between the groups (age and conservation status).

$H_4$ - The corneal reflections (fixations) will not be distributed evenly over the four quadrants (see figure 2) of the illusion stimulus for all groups (age and conservation status).

$H_5$ - An unequal distribution of corneal reflections will not occur between the arrow and feather figures for any of the groups (age and conservation status).

$H_6$ - All groups (age and conservation status) will concentrate their fixations (corneal reflections) on the more informative areas of the illusion stimulus.

$H_7$ - Mean track length will not vary significantly over the type of position of the illusion stimulus or the type of verbal instruction for any of the groups (age and conservation status).

$H_8$ - Mean track length will vary significantly over the number of trials of stimulus presentation for all groups (age and conservation status).

$H_9$ - Mean track length will not vary significantly over the number of trials of stimulus presentation between groups (age and conservation status).

## Data Analysis II

### Hypothesis 1

Hypothesis 1 was tested using a three way analysis of variance design with repeated measures on two factors (position of illusion and verbal instruction) (see Winer, 1962, p. 319). The results as given in tables XV and XVI supported hypothesis 1 in all respects.

TABLE XV

COMPARISON OF AGE GROUPS ON SCANNING LATENCY

Summary of Analysis of Variance

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BET SUBJ | 36041.50 | 74 | | | |
| A | 66.94 | 2 | 33.47 | 0.07 | 0.94 |
| SUBJ W GROUP | 35974.56 | 74 | 499.65 | | |
| WITHIN SUBJ | 79193.50 | 375 | | | |
| B | 319.63 | 1 | 319.63 | 2.31 | 0.13 |
| AB | 173.00 | 2 | 86.50 | .63 | 0.54 |
| B X SUBJ W G | 9948.88 | 72 | 138.18 | | |
| C | 63.56 | 2 | 31.78 | 0.16 | 0.85 |
| AC | 675.86 | 4 | 168.96 | 0.84 | 0.50 |
| C X SUBJ W G | 29029.56 | 144 | 201.59 | | |
| BC | 750.87 | 2 | 375.43 | 1.44 | 0.23 |
| ABC | 749.13 | 4 | 187.28 | 0.02 | 0.99 |
| BC X SUBJ W C | 37483.50 | 144 | 260.30 | | |

A-Subjects B-Position of illusion C-Verbal instruction

TABLE XVI

COMPARISON OF SELECTED CONSERVATION STATUS

GROUPS ON SCANNING LATENCY

Summary of Analysis of Variance

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BET SUBJ | 17161.25 | 35 | | | |
| A | 665.00 | 1 | 665.00 | 1.37 | 0.25 |
| SUBJ W GROUP | 16496.25 | 34 | 485.18 | | |
| WITHIN SUBJ | 39559.50 | 180 | | | |
| B | 18.31 | 1 | 18.31 | 0.13 | 0.72 |
| AB | 447.86 | 1 | 447.88 | 3.18 | 0.08 |
| B X SUBJ W G | 4781.94 | 34 | 140.65 | | |
| C | 206.63 | 2 | 103.31 | 0.52 | 0.60 |
| AC | 143.50 | 2 | 71.75 | 0.36 | 0.70 |
| C X SUBJ W G | 13574.88 | 68 | 199.63 | | |
| BC | 870.56 | 2 | 435.28 | 1.59 | 0.21 |
| ABC | 937.81 | 2 | 468.91 | 0.01 | 0.99 |
| BC X SUBJ W G | 18578.00 | 68 | 273.21 | | |

A-Subjects B-Position of illusion C-Verbal instruction

Hypothesis 2 and 3

Hypothesis 2 and 3 were tested using a two way analysis of variance design with repeated measures on the factor of number of trials.

The results as given in tables XVII and XVIII supported the hypothesis in all respects.

TABLE XVII

COMPARISON OF AGE GROUPS ON SCANNING LATENCY OVER TRIALS

Summary of Analysis of Variance

| Source of Variation | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN SUBJECTS | 36041.500 | 74 | | | |
| 'A ' MAIN EFFECTS | 66.797 | 2 | 33.398 | 0.067 | 0.94 |
| SUBJECTS WITHIN GROUPS | 35974.625 | 72 | 499.647 | | |
| WITHIN SUBJECTS | 79193.500 | 375 | | | |
| 'B' MAIN EFFECTS | 15765.242 | 5 | 3153.048 | 18.458 | 0.0000 |
| 'A*B' INTERACTION | 1930.079 | 10 | 193.008 | 1.130 | 0.33 |
| 'B' X SUBJ WITHIN GROUPS | 61497,562 | 360 | 170.827 | | |

A--Subjects B-Trials

TABLE XVIII

COMPARISON OF CONSERVATION STATUS GROUPS
ON SCANNING LATENCY OVER TRIALS

Summary of Analysis of Variance

| SOURCE OF VARIATION | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN SUBJECTS | 17161.250 | 35 | | | |
| 'A' MAIN EFFECTS | 664.945 | 1 | 664.945 | 1.371 | 0.249 |
| SUBJECTS WITHIN GROUPS | 16496.187 | 34 | 485.182 | | |
| WITHIN SUBJECTS | 39559.500 | 180 | | | |
| 'B' MAIN EFFECTS | 8348.625 | 5 | 1669.725 | 9.345 | 0.000 |
| 'A*B' INTERACTION | 834.398 | 5 | 166.880 | 0.934 | 0.460 |
| 'B' X SUBJ WITHIN GROUPS | 30376.437 | 170 | 178.685 | | |

A-Subjects B-Trials

Hypothesis 4

Each subject on every trial was classified as either distributing his fixations equally amongst the four quadrants (see Figure 2) of the illusion stimulus or not equally. This was accomplished by means of a chi square test (goodness of fit for four categories with the expected frequency for each category equal to one quarter of the total number of fixations for a particular presentation). The number of fixations in each quadrant were summed for each subject on each trial and tested by chi square. After the subjects were classified into two categories (equal distribution of fixations or unequal distribution of fixations) a chi square test (goodness of fit for two categories with the expected frequency of P = .5) was used to test if for a

TABLE XVII-B

NEWMAN-KEULS TEST ON MEANS FOR AGE GROUPS ON SCANNING LATENCY OVER TRIALS

| | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| T1 | | ** | ** | ** | ** | ** |
| T2 | | | - | - | - | - |
| T3 | | | | - | - | - |
| T4 | | | | | - | - |
| T5 | | | | | | - |

T - Trial
* - significance at the .05 level
** - significance at the .01 level

TABLE XVIII-B

NEWMAN-KEULS TEST ON MEANS FOR CONSERVATION STATUS GROUPS ON SCANNING LATENCY OVER TRIALS

| | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| T1 | | * | ** | ** | ** | ** |
| T2 | | | - | - | - | ** |
| T3 | | | | - | - | - |
| T4 | | | | | - | - |
| T5 | | | | | | - |

T - Trials
* - Significance at the .05 level
** - Significance at the .01 level

TABLE XIX

SUMMARY OF QUADRANT ANALYSIS ON FIXATIONS OVER TRIALS

| | TRIAL | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| AGE GROUP 1 | S 19, NS 6; $X^2$ = 6.76 | S 19, NS 6; $X^2$ = 6.76 | S 18, NS 7; $X^2$ = 4.84 | S 23, NS 3; $X^2$ = 17.6 | S 18, NS 7; $X^2$ = 4.84 | S 19, NS 6; $X^2$ = 6.76 |
| AGE GROUP 2 | S 20, NS 5; $X^2$ = 9.0 | S 20, NS 5; $X^2$ = 9.0 | S 19, NS 6; X2 = 6.76 | S 19, NS 6; $X^2$ = 6.76 | S 22, NS 3; $X^2$ = 14.4 | S 25, NS 0; $X^2$ = 25.0 |
| AGE GROUP 3 | S 19, NS 6; $X^2$ = 6.76 | S 18, NS 7; $X^2$ = 4.84 | S 19, NS 6; $X^2$ = 6.76 | S 18, NS 7; $X^2$ = 4.84 | S 22, NS 3; $X^2$ = 14.4 | S 21, NS 4; $X^2$ = 11.6 |
| CONSERVERS | S 16, NS 2; $X^2$ = 10.9 | S 15, NS 3; $X^2$ = 8.0 | S 14, NS 4; $X^2$ = 5.6 | S 16, NS 2; $X^2$ = 10.9 | S 17, NS 1; $X^2$ = 14.2 | S 15, NS 3; $X^2$ = 8.0 |
| NONCONSERVERS | S 15, NS 3; $X^2$ = 8.0 | S 14, NS 4; $X^2$ = 5.6 | S 18, NS 0; $X^2$ = 18.0 | S 17, NS 1; $X^2$ = 14.2 | S 14, NS 4; $X^2$ = 5.6 | S 16, NS 2; $X^2$ = 10.9 |

S - subjects distributing fixations equally over quadrants .05 - 3.84

NS - subjects distributing fixations unequally over quadrants .01 - 6.64

particular group more subjects existed who scanned the four quadrants equally than subjects who scanned the quadrants unequally. The results indicated that for all groups on all trials hypothesis 4 was substantiated. To test for differences between groups a chi square for K independent samples was used (Siegel, 1956). The results indicated no differences between groups.

Hypothesis 5

To test for hypothesis 5 the fixations summed for each quadrant in testing for hypothesis 4 were combined (quadrant I and quadrant II were summed and quadrant III was summed with quadrant IV--see Figure 2). Each group was analyzed (using a chi square goodness of fit for two categories with P = .5). The results indicated that over trials, different verbal instructions and different positions of the illusion stimulus subjects did not differ significantly in choosing either the arrow or the feather when they in fact did give a biased scan (significantly more fixations on either the arrow or feather figure).

Hypothesis 6

To investigate hypothesis 6 the mean number of fixations (corneal reflections) in each cell (see Figure 2) for particular groups (age and conservation status) were calculated on each trial. From observing the data it was evident that a striking similarity in mean number of fixations per cell was evident between groups on all trials. The groups were pooled and the mean number of fixations for the total sample on trials one and six were plotted on a graph

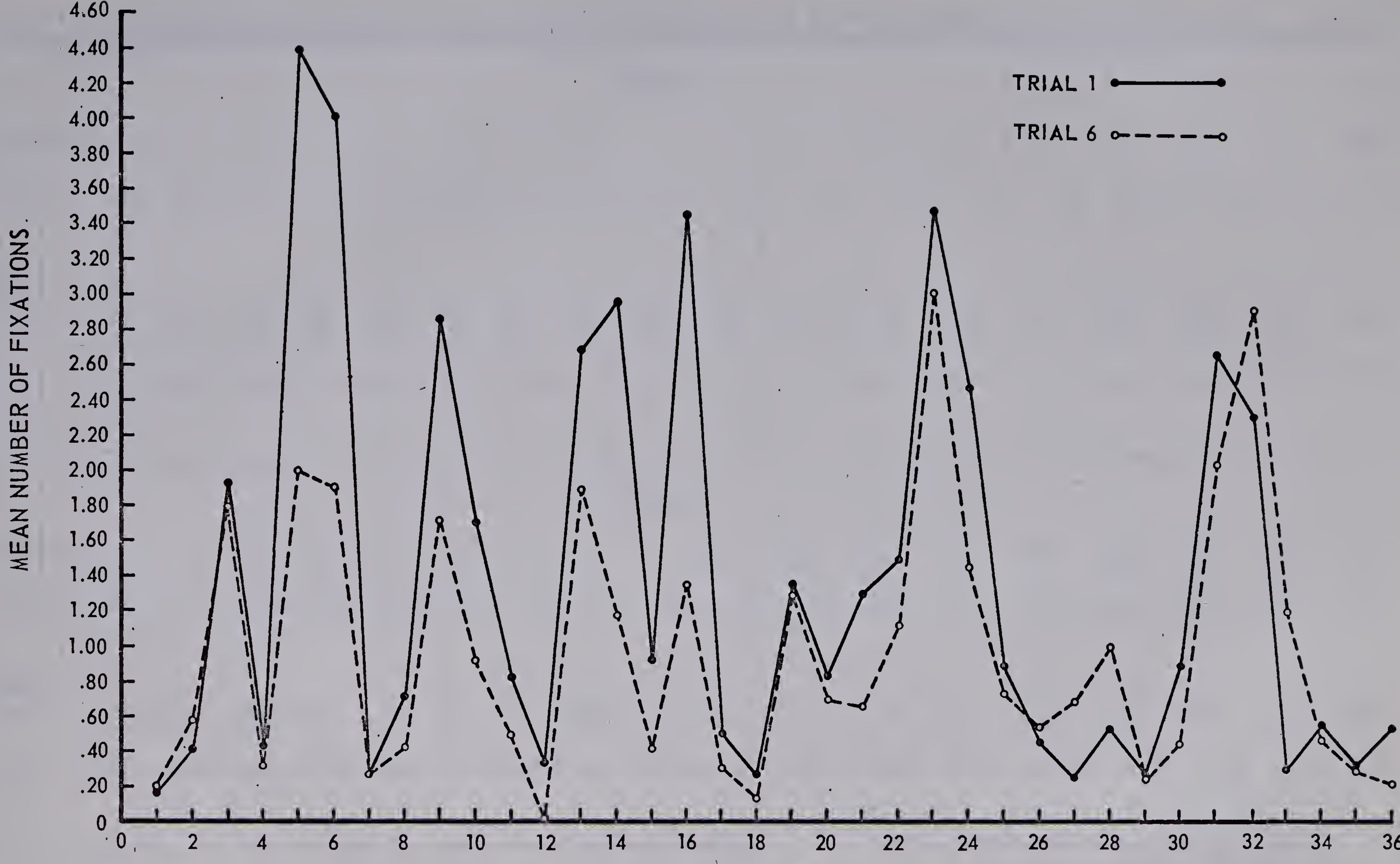



FIG. 3 Graph of mean number of eye fixations in each stimulus area of the Muller-Lyer illusion as designated by cell for total sample (75 subjects) on first and last trials.

TABLE XX

STANDARD DEVIATIONS OF MEAN FIXATIONS PER CELL FOR SAMPLE ON TRIALS ONE AND SIX

TRIAL 1

| CELL NO.: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD | .82 | 1.31 | 4.64 | 1.76 | 7.24 | 4.96 | 1.33 | 1.65 | 3.94 | 3.99 | 2.39 | 1.62 | 3.76 | 5.00 | 2.54 | 3.75 | 1.41 | 1.14 |

| CELL NO.: | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD | 3.14 | 1.80 | 2.81 | 3.73 | 4.05 | 3.77 | 3.28 | 1.37 | 1.14 | 1.37 | .93 | 3.07 | 3.46 | 3.80 | 1.60 | 1.40 | 1.42 | 2.66 |

TRIAL 2

| CELL NO.: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD | .72 | 1.86 | 3.44 | 1.26 | 4.15 | 3.31 | .97 | 1.25 | 4.01 | 1.80 | 1.70 | .16 | 7.24 | 3.19 | 2.28 | 5.90 | 1.19 | .98 |

| CELL NO.: | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD | 3.22 | 1.71 | 1.52 | 2.67 | 4.09 | 2.13 | 2.03 | 1.34 | 1.50 | 2.78 | .70 | 1.91 | 3.23 | 10.93 | 8.11 | 1.49 | 1.16 | .70 |

CELL NO. - See Figure 2, areas on illusion stimulus

SD - Standard Deviation on mean fixations per cell for total sample (75).

as illustrated in Figure 3. The graph illustrates that modes arise over the most informative cells (cells 5, 14, 23, 32). Also, the graph illustrates that fixations on the stimulus areas of the arrow figure (cells 1 to 18) (see Figure 2) are more centered towards the middle of the arrow while on the stimulus areas of the feather figure (cells 19 to 36) fixations are not as centered. Since the trial by trial comparison of mean number of fixations per cell for the particular groups indicated practically identical distributions and since the reliability of comparing the number of fixations over such small areas was questionable no further statistical analyses are reported for testing hypothesis 6. The experimenter was only concerned in observing a possible trend in the distribution of fixations at the cell level. There was a definite indication that all groups were equally competent in concentrating their fixations at the more informative areas of the illusion stimulus (in terms of the task presented to the subject). However for a more valid analysis at the cell level (for a comparison of the number of fixations in different areas) an analysis of the same data with a different definition for "fixation" should be made (one allowing for variable latency per fixation).

Hypothesis 7

Hypothesis 7 was tested by means of a three way analysis of variance design with repeated measures of the two factors of position and verbal instruction. The results as indicated in tables XX and XXI supported the hypothesis in all respects.

TABLE XXI

COMPARISON OF AGE GROUPS ON MEAN TRACK LENGTH

Summary of Analysis of Variance

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BET SUBJ | 2472.18 | 74 | | | |
| A | 77.37 | 2 | 38.68 | 1.16 | 0.318 |
| SUBJ W GROUP | 2394.81 | 72 | 33.26 | | |
| WITHIN SUBJ | 3625.43 | 375 | | | |
| B | 9.68 | 1 | 9.68 | 0.85 | 0.358 |
| AB | 2.25 | 2 | 1.12 | 0.10 | 0.905 |
| B X SUBJ W G | 818.31 | 72 | 11.36 | | |
| C | 23.43 | 2 | 11.71 | 1.23 | 0.296 |
| AC | 23.62 | 4 | 5.90 | 0.62 | 0.650 |
| C X SUBJ W G | 1375.93 | 144 | 9.55 | | |
| BC | 15.43 | 2 | 7.71 | 0.82 | 0.440 |
| ABC | 7.68 | 4 | 1.92 | 0.43 | 0.788 |
| BC X SUBJ W G | 1349.06 | 144 | 9.36 | | |

A-Subjects B-Position of illusion C-Verbal instruction

TABLE XXII

COMPARISON OF CONSERVATION STATUS GROUPS

ON MEAN TRACK LENGTH

Summary of Analysis of Variance

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BET SUBJ | 1170.55 | 34 | | | |
| A | 2.80 | 1 | 2.80 | 0.08 | 0.776 |
| SUBJ W GROUP | 1167.74 | 34 | 34.34 | | |
| WITHIN SUBJ | 1441.05 | 180 | | | |
| B | 24.34 | 1 | 24.34 | 2.61 | 0.115 |
| AB | 0.89 | 1 | 0.89 | 0.10 | 0.758 |
| B X SUBJ W G | 317.08 | 34 | 9.32 | | |
| C | 1.37 | 2 | 0.68 | 0.09 | 0.915 |
| AC | 27.23 | 2 | 13.61 | 1.74 | 0.182 |
| C X SUBJ W G | 531.44 | 68 | 7.81 | | |
| BC | 7.97 | 2 | 3.98 | 0.53 | 0.591 |
| ABC | 18.43 | 2 | 9.21 | 0.27 | 0.767 |
| BC X SUBJ W G | 512.31 | 68 | 7.53 | | |

A-Subjects B-Position of illusion C-Verbal instruction

Hypotheses 8 and 9

Hypotheses 8 and 9 were tested by means of a two way analysis of variance with repeated measures on the factor of (trials). The results as indicated in Tables XXII and XXIII supported hypothesis 9 but not hypothesis 8.

TABLE XXIII

COMPARISON OF AGE GROUPS ON MEAN TRACK LENGTH OVER TRIALS

SUMMARY OF ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN SUBJECTS | 2471.687 | 74 | | | |
| 'A' MAIN EFFECTS | 77.423 | 2 | 38.712 | 1.164 | 0.317 |
| SUBJECTS WITHIN GROUPS | 2394.187 | 72 | 33.253 | | |
| WITHIN SUBJECTS | 3630.000 | 375 | | | |
| 'B' MAIN EFFECTS | 36.536 | 5 | 7.307 | 0.744 | 0.591 |
| 'A*B' INTERACTION | 58.136 | 10 | 5.814 | 0.592 | 0.820 |
| 'B' X SUBJ WITHIN GROUPS | 3535.562 | 360 | 9.821 | | |

A-Subjects B-Trials

TABLE XXIV

COMPARISON OF CONSERVATION STATUS GROUPS ON MEAN TRACK LENGTH OVER TRIALS

SUMMARY OF ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| BETWEEN SUBJECTS | 6713.992 | 35 | | | |
| 'A' MAIN EFFECTS | 19.736 | 1 | 19.736 | 0.100 | 0.753 |
| SUBJECTS WITHIN GROUPS | 6694.246 | 34 | 196.890 | | |
| WITHIN SUBJECTS | 2170.937 | 180 | | | |
| 'B' MAIN EFFECTS | 107.604 | 5 | 21.521 | 1.809 | 0.113 |
| 'A*B' INTERACTION | 40.557 | 5 | 8.111 | 0.682 | 0.637 |
| 'B' X SUBJ WITHIN GROUPS | 2022.824 | 170 | 11.899 | | |

A-Subjects B-Trials

Reliability and Validity II

As discussed in the section of the thesis called Pilot Work the reliability of responses (in terms of susceptibility to the illusion) to the illusion on the camera was checked by having a control group scan the same illusion in a desk presentation. No differences were observed between subjects observing the illusion on the viewing screen with subjects viewing the illusion on a card.

The accuracy of calibration as based on the instrumentation of the eye movement camera apparatus is within about a circular area having a 2cm. diameter. For each stimulus presentation the accuracy of calibration could be checked on the developed film. If a deviation from the target was observed the analysis of the subsequent corneal reflections was carried with a displacement of the loci of fixations in an identical direction to that observed in calibration. The scoring of the fixations was carried out with a grid overlay (similar to Figure 2) placed on a drawn replica of the illusion stimulus. The scoring of the fixations was rechecked two times by the experimenter and once by another individual with a resultant agreement between scoring trials of 92%.

Since the eye spot accuracy is within an area approximate to the size of a 25¢ piece and since the cell areas were 1 inch by 1 inch the analysis at the cell level was kept at a minimum. If the cells had not been adjacent to one another ( an inert space in-between cells) greater reliability in analyzing fixations at the cell level would have been possible. Also, due to the nature of the Muller-Lyer illusion cell areas adjacent to each other were sometimes at extremes in terms

of information context so that a slight shift to an adjacent cell of a fixation could have been misinterpreted with respect to scanning for information content.

The four stimuli presented after the six trials of the illusion stimulus were deemed essential as controls for the subjects' answers to the questions asked during the presentation of the original illusion stimulus.

The modified stimulus (where the solid lines were changed in length--see Procedure) was presented as a check against the formation of an identification response on the part of the subject. It could have been that after the first few trials the subjects were merely locating the figure they had already decided was longer or shorter and that they were basing their answers on scan which was not concerned with comparing the lengths of the solid lines. The modified stimulus was such that if a subject had in fact made his decision on the basis of which figure (arrow or feather) extended further in a horizontal direction he should have continued to choose the same figure as being longer. The results were that although all of the subjects continuously concluded that the feather solid line was longer, when the modified illusion stimulus was presented all subjects could discriminate the change in length of the solid lines. Thus a set was not necessarily occurring even though the number of fixations over trials were reduced. Several of the subjects considered the modified solid lines to be of equal length which is also in keeping with the weakening of the illusion. With the stimulus involving the two parallel lines, all subjects maintained that they were of equal length.

## Discussion II

### Hypothesis 1

The results of hypothesis 1 indicate that either the verbal instructions were neutral (not direct enough to create specific orientations to the longer or shorter lines--phenomenally) or that verbal instructions with respect to the task and stimulus involved were unimportant in causing the subject to change his latency of scanning. The instruction containing the word "same" was considered to be different from the other two instructions in that it was more ambiguous (since both lines were solid but phenomenally of different lengths.) However, no observable effect was present from the instruction which was not present with the other two instructions.

### Hypothesis 2 and 3

From the fact that each of the six trials were highly similar in terms of stimulus presentation it was not surprizing to observe that scanning latency reduced over trials. The fear that a mere "identification" response would develop (a quick scan to check where the figure was that the subject had decided was longer or shorter on the first couple of trials instead of visually measuring the solid lines) was not realized (see Reliability and Validity--modified illusion stimulus).

### Hypothesis 4 and 5

The realization of hypothesis 4 tends to imply that in fact the subjects' scanning of the illusion stimulus was poor (in terms of decentration--Piaget 1960) and that all groups were similar in their

scanning. An alternative interpretation would be that the examination of the solid lines in terms of solving the task proceeded in a two step fashion. Perhaps an initial careful examination of one of the lines was followed by a quick shift to the other line for a "matching" check which was quite short in latency. This would explain why irrespective of which figure had more fixations (arrow or feather) the occurrence of a disproportionate distribution of fixations over the quadrants was quite common.

Hypothesis 6

The close agreement between the mean number of fixations per cell for all of the groups on all of the trials (as partly illustrated in Figure 3) indicates that the tasks were meaningfully comprehended by younger and older subjects alike. Hypothesis 6 should be tested with the same data but with a different definition of fixation so that pooling of insignificant shifts in fixation could take place. It may then be apparent that differences in fixations do exist on the more informative areas of the stimulus. However such a procedure would have to take into account the unreliability of comparisons on small stimulus areas as well as adjacent extremes in information value inherent in the illusion stimulus.

Hypotheses 7, 8 and 9

The lack of differences in tracking length for the age groups as well as the conservation status groups indicates the possibility that in fact conservers and nonconservers although differing in cognitive capacities do not display differences in their perceptual activity. The argument for the existence of partial isomorphisms

between perception and intelligence (Piaget, 1960; Flavell, 1963) would imply that relative to the tasks presented involving the illusion stimulus the conservers should have displayed a greater mean tracklength than the nonconservers. Similarly, the older subjects should have displayed a greater mean tracklength than the younger subjects. The author feels however, that especially with respect to the hypotheses involving tracklength no strong argument should be proposed till the data is analyzed in terms of a definition of fixation allowing for a variable latency of fixation. The author proposes that even with such an analysis the results will indicate no differences between the groups. Considering the nature of the stimulus (Muller-Lyer illusion) used to receive the subjects' scanning it is not surprizing that the groups did not differ in their responses. As Yarbus (1967) maintains, a stimulus as powerful as the Muller-Lyer illusion (in terms of a phenomenal-real discrepancy) tends to manipulate eye movements rather than have eye movements manipulate it. The concentration of fixations in the middle of the arrow figure tends to give support to such a notion.

## PART III

### Sample III

The sample consisted of the same 75 subjects that were selected for part I of the study. One subject was randomly chosen and discarded from the sample to allow for the formation of two equal subgroups.

### Apparatus III

The materials consisted of:

1. two pieces of straight black wire (12cm. long and .25cm. in diameter);
2. two strips of black cardboard (20cm. x .5cm.) and two strips of black cardboard (4cm. x .5cm.);
3. two pieces of black cardboard (3cm. x 3cm.) and a magnifying glass (diameter of 6cm.);
4. one drinking glass and two pennies;
5. a rectangular container made of clear plastic (10cm. x 5cm. x 2cm.) and a straight black wire (15cm. long and .25cm. in diameter);
6. a plastic ring (diameter of 10cm.), and a desk lamp ;
7. two pieces of red plastic (5cm. x 5cm.), a red glass color filter, and an ordinary piece of red glass;
8. an opaque bowl (12cm. in diameter) and a straight black wire (22cm. long and .25cm. in diameter);
9. a photograph showing a lion with some skyscrapers in the background (20cm. x 36cm.);

10. a photograph of a coin (5cm. in diameter) displaying a man's bust and another photograph of the same man's bust (same size as on the coin).

Procedure III

Each subject was presented with ten tasks designed to elicit differential responses to the phenomenal and real aspects of a stimulus situation and eight tasks that acted as controls (non-illusory transformations) for particular phenomenal-real discrimination tasks. Two of the phenomenal-real discrimination tasks did not have controls due to the use of photographs as stimuli. The ten discrimination tasks were presented in a random order to each subject and a particular task was alternated in order of presentation with its corresponding control task for one half of the sample. For both the discrimination tasks and their controls each subject was asked two questions which were alternated in order for one half of the sample. The subjects were asked 1) how the stimulus in question looked, and 2) how it really was. Subjects were chosen randomly for different orders of tasks and instructions.

Subjects were scored as 1 (passing the task) if they responded to the apparent aspects of the stimulus problem, viz. "How does it look?" and if they responded to the real aspects of the stimulus problem with respect to the second question, viz. "How is it really?" Also, a correct response was required on each corresponding control task. If the subject gave a correct answer in terms of the phenomenal aspects of the stimulus situation to both questions he was classified as 0 (failing the task). An incorrect response to the corresponding

control task (a different answer to the real aspects of the stimulus situation from the one to the apparent aspects) was also sufficient to classify the subject as having failed the discrimination task. Subjects not responding correctly to the apparent (phenomenal) aspects of the stimulus situation were discarded from the sample since no decision could be made about whether they were aware of an illusion.

The following tasks were presented to the subjects:

Task 1

Two straight black wires were shown to be of equal length by juxtaposition. The two pieces of wire were then placed into relative positions resembling an inverted T (horizontal-vertical illusion). The subject was then asked the following questions: "Does one line look longer than the other line?" and "Is one line really longer than the other line?"

Control Task

The control task involved the same procedure as task 1 except that the two pieces of wire were placed into the relative positions of one wire being 4 inches above the other wire (with the edges of wires in line with each other and the wires parallel to each other).

Task 2

Two short strips of black cardboard were juxtaposed then spread apart 10 cm. Two long strips of black cardboard were placed on either ends of the short strips to form the Ponzo illusion. The subject was then questioned about the apparent and real aspects of the two short strips as follows: "Does one strip (short strip indicated) look longer

than the other strip (other short strip indicated)?" and "Is one strip really longer than the other strip?" (strips indicated).

Control Task

The same procedure was carried out as for task 2 except that the two long strips were placed parallel to each other.

Task 3

The subject was shown two black cardboard squares of equal area placed side by side on a table. A magnifying glass was placed over one of the squares and the subject was questioned about the apparent and the real sizes of the squares as follows: "Does one black piece look as big as the other piece?" and "Is one black piece really as big as the other piece?"

Control Task

The same procedure was carried out as for task 3 except that an ordinary piece of glass was substituted for the magnifying glass.

Task 4

Two pennies were viewed side by side then one penny was placed at the bottom of a clear glass of water and the subject was questioned about the real and apparent sizes of the two pennies as follows: "Does one penny look bigger than the other penny?" and "Is one penny really bigger than the other penny?"

Control Task

The same procedure was used as in task 4 except that an empty drinking glass was substituted for a glass filled with water.

Task 5

A straight black wire was observed lying on the table then one end was immersed in a corner of a clear plastic container half filled with water. The subject was questioned about the apparent and real number of wires as follows: "Does it look like there is more than one wire in the water?" and "Is there really more than one wire in the water?" The wire in the container was observed from the corner of the container containing the wire.

Control Task

The same procedure was used as in task 5 except that the wire in the container was observed directly from the top of the container.

Task 6

The room was darkened and a desk lamp was turned on. The round shadow of a plastic ring was cast onto a wall (after the subject has seen the plastic ring on the table) and then the experimenter turned the ring 45° so that an elliptical shadow was created. The subject was questioned about the apparent and real shape of the ring as follows: "Does the ring look as if it ws squeezed together?" and "Is the ring really squeezed together?"

Control Task

The same procedure was used as in task 6 except that the ring was rotated 180° instead of 45°.

Task 7

Two pieces of red plastic were viewed on the table then a red color filter was placed over one of the plastic pieces (making it appear

black) and the subject was asked about the apparent and real colors of the plastic pieces as follows: "Does the color of one piece look different from the color of the other piece?" and "Is one piece really a different color than the other piece?"

Control Task

The same procedure was used as in task 7 except that an ordinary piece of red glass was placed over one of the pieces of plastic.

Task 8

A straight black wire was observed on the table then one end of the wire was immersed in an opaque bowl half filled with water. The subject was questioned about the apparent and real straightness of the wire as follows: "Does the wire look bent?" and "Is the wire really bent?" The subject viewed the wire in the bowl from the edge of the bowl.

Control Task

The same procedure was used as in task 8 except that the subject viewed the wire directly from the top of the bowl.

Task 9

A photograph showing a lion with some skyscrapers in the background was viewed by the subject and questions about the real and apparent size of the objects in the photograph were as follows: "Does the lion look like it is bigger than the buildings?" and "Is the lion really bigger than the buildings?"

Task 10

A photograph of a coin displaying a man's bust and another photograph of the same bust were viewed by the subject and questions about the real and apparent size of the man were as follows: "Does the man look as big as he is on the coin?" and "Is the man really as big as he is on the coin?"

Hypothesis III

$H_1$ - Phenomenal-real discrimination (as measured by pass and fail responses to the phenomenal-real discrimination tasks) will be more prevalent in the older subjects.

$H_2$ - Phenomenal-real discrimination will be more prevalent amongst the conservers than the nonconservers.

$H_3$ - Subjects who pass or fail particular conservation tasks (length and area) will be consistent in their responses to phenomenal-real discrimination tasks on similar dimensions (length and area).

Data Analysis III

Since all of the subjects in the sample passed every task no statistical analyses were carried out to test the hypotheses for part three. A chi square for independent groups was to be used in testing the first hypothesis ($H_1$) with respect to the age groups. The second hypothesis ($H_2$) was to be tested on the conserver and nonconserver groups, again using a chi square for independent groups. For hypotheses one and two each phenomenal-real discrimination task was to be analyzed separately. To test if the number of realists (subjects

who passed the phenomenal-real discrimination tasks) differed from task to task a cochran Q test (Siegel, 1956) would have been used. Hypothesis three ($H_3$) was concerned with responses to phenomenal-real discrimination tasks involved with the dimensions of length and area (tasks 1, 2, 3, 4). A McNemar test (Siegel, 1956) would have been used to test if subjects who passed or failed a task involving the conservation of length (see chapter IV, part I) would be consistent in passing or failing a task involving the phenomenal-real discrimination of length. A similar analysis would have been performed for tasks involving conservation and phenomenal-real discrimination of area.

Reliability and Validity III

The phenomenal-real discrimination tasks were based on the definition of phenomenal-real discrimination given on page 2 of the thesis. This definition is closely related to the definition of optical illusions given by Underwood (1966). Many of the tasks resemble those used by Murray (1966) in testing for phenomenal-real discrimination. Task 9 and 10 were included to add further variety to questions about apparent and real aspects of a stimulus situation but the more important tasks were those dealing with questions of length, area and size. It has been proposed (Braine and Shanks, 1965; Murray, 1966) that the abilities of conservation and phenomenal-real discrimination are very closely related and that both abilities involve similar considerations. The phenomenal-real discrimination tasks used in the thesis required understanding of a similar nature

to that required for the conservation tasks.

Randomization was used to control for order effects of task presentation and each phenomenal-real discrimination task (tasks 1 to 8) was accompanied by a control task involving non-illusory transformations.

## Discussion III

The results indicated that in terms of the tasks used to measure the presence or absence of phenomenal-real discrimination, no differences existed between subjects of different ages or conservation status. It may be mentioned that the particular tasks used to test for phenomenal-real discrimination ranged from problems involving dimensions of length, area and size to qualitative problems involving shape and photographs of animate objects. Since the tasks were presented randomly, an absence of phenomenal-real discrimination should have been observed on at least some of the tasks if in fact an absence of phenomenal-real discrimination existed for any of the subjects.

The findings did not support the proposal of Murray (1966) that length conservation rests upon a general phenomenal-real discrimination of length nor did they support the hypothesis of Braine and Shanks (1965) that conservation depends upon a general phenomenal-real discrimination capacity. Both the nonconservers as well as the conservers possessed a capacity for phenomenal-real discrimination. The tasks used by the author to test for phenomenal-real discrimination were similar to those used by Murray (1966), but it may be that results

more in agreement with those of Murray (1966) and those of Braine and Shanks (1965) would have occurred if the sample would have included subjects in a younger age range (four and one half years to six and one half years). The results are in agreement with the author's opinion that although phenomenal-real discrimination may be meaningfully related to conservation the relationship between the two abilities need not be direct. It may be that before a nonconserver realizes the similarity between the concepts of conservation and phenomenal-real discrimination or before he is aware that an inconsistency exists between a nonconservation response to a conservation task and a successful phenomenal-real discrimination response to a task on the same dimension he must acquire further associations or discriminations. In conservation tasks perceptual cues exist other than ones pertinent to phenomenal-real discrimination. The nonconserver must be able to successfully interpret the roles of all such cues as well as transformations being performed on the objects involved in the conservation tasks and evaluate their relationship to purely quantitative concepts. This requires a further sophistication of the subject's quantitative concepts as well as an accompanying congruent interpretation of perceptual cues. The latter point is discussed in Chapter IV, Part IV.

# PART IV

## Sample IV

The sample consisted of 40 nonconservers (on the basis of conservation of length, mass, area and liquid continuous quantity pretests) 20 of which were randomly chosen for a treatment group and 20 were designated as a control. Treatment and control groups were compared on age, IQ and socio-economic status. Since most subjects had already participated in part one of the study, comparisons on independent variables were possible from data already recorded. Six additional subjects from the pilot studies were included in the sample. Three were randomly allocated to the treatment group and three were included in the control group.

TABLE XXV

COMPARISON OF TREATMENT AND CONTROL GROUPS ON INDEPENDENT VARIABLES

| VARIABLE | TREATMENT GROUP | | CONTROL GROUP | | F |
|---|---|---|---|---|---|
| | mean | variance | mean | variance | |
| AGE | 92.50 | 100.59 | 93.85 | 94.39 | 1.06 -- |
| IQ | 103.00 | 88.50 | 102.10 | 92.06 | 1.04 -- |
| BS | 49.83 | 61.62 | 48.22 | 46.92 | 1.31 -- |

IQ - Detroit Beginners Intelligence Test
BS - Blishen Scale Rating
F - Test for homogeneity of variance
-- - nonsignificance at .05 level

Apparatus IV

The materials for the pretest and the postest were the same as used for the conservation tasks in Part I of the thesis. The materials used during training as listed below.

1. Two strips of black cardboard (9cm. long and .5cm. wide) and four L shape strips of black cardboard (each side 3cm. long and .5cm. wide);

2. One strip of yellow cardboard (12cm. long and 1cm. wide) and one strip of red cardboard (12cm. long and 1cm. wide);

3. One silver tablespoon;

4. Two equal pieces of plasticine (2.5cm. in diameter and 10cm. long, red in color);

5. Two balls of plasticine yellow in color (7cm. in diameter);

6. Two cakes of red plasticine (6cm. in diameter and 2.5cm. in height);

7. Magnifying glass (6cm. in diameter) and a black cardboard cutout of a little dog (2cm. in height);

8. One bowl (12cm. in diameter) and one straight black wire (20cm. long and .25cm. in diameter);

9. Two sheets of red paper (24cm. x 18cm.);

10. A pair of scissors.

Procedure IV

Each subject was trained individually in a separate room that was removed from distracting influences. Since the experimenter had an opportunity to meet all of the subjects on several previous occasions little difficulty was experienced in developing a good rapport

with the subjects. All of the control subjects were brought into the same experimental setting as the treatment subjects except that no training was attempted with the controls. The experimenter merely questioned the control subjects on topics like their school activities and their hobbies.

The procedure used with the treatment group involved the following steps:

1. The establishment of a rapport with the subject.

2. Communicating with the subject on the perceptual aspects of objects which were meaningful and obvious to the subject. (This is especially appropriate with subjects who are approaching Piaget's so-called stage of concrete operations).

3. Providing vivid examples of perceptual situations which possessed striking phenomenal-real discrepancies (to orient the subject on the phenomenal-real discrepancies of objects and to foster the emergence of a skepticism about perceptual impressions).

4. A reinforcement of the skepticism generated in (3) above by presenting the subject with a variety of phenomenal-real discrepancies.

5. Emphasizing the misleading nature of perception and instilling in the subject the question of whether another more superior and effective means existed for knowing the true aspects of a situation (concrete objects).

6. Emphasizing the question instilled in (4) above with the term "real" and distinguishing the category of "real" from the phenomenal aspects ("looks").

7. Questioning the subject about a means of knowing the real aspects of a situation and applying this question to concrete objects

in terms of their quantity and perceptual aspects.

8. Instilling an "identity" criterion under the "real" category as discussed with phenomenal-real discrepancies and a perceptual criterion ("looks" like) under the phenomenal category of phenomenal-real discrepancies. In the latter case all perceptual attributes (illusory and non-illusory were included under the phenomenal category ("looks"). This provided a means for the experimenter to have the subject differentiate all state attributes from quantitative transformations ("identity" criterion under the "real" category).

9. Applying the points discussed in (8) above first to length conservation tasks and then tasks of mass and area conservation.

10. Emphasizing in each task (9) the distinction between the phenomenal and real aspects inherent in the objects.

11. Having the subject give the conservation tasks to the experimenter (to foster reinforcement and clarification of the conservation task for the subject). The experimenter gave a wrong response to the conservation task and then asked the subject to tell him if he was wrong or right and why.

12. The experimenter and the subject discussed why identity reasons (real aspects) were better than "looking" reasons (phenomenal aspects) in determining quantity in concrete objects (emphasizing the necessity of quantitative equivalence in terms of an identity criterion and the non-necessity of quantitative equivalence in terms of a phenomenal or perceptual criterion).

It should be emphasized that the above steps attempted to de-emphasize the role of misleading perceptual cues by illustrating

the uncertainty of phenomenal aspects in concrete situations while attempting to emphasize the role of quantitative transformations in terms of an identity criterion which was initially categorized under the "real" category involved with phenomenal-real discrimination.

Step (2) was carried out with the use of various concrete objects such as aspects of the room, objects on the table.

Step (3) was carried out using strips of black cardboard to form a Muller-Lyer illusion. The two middle lines of the illusion were separated from the wings so that a vivid perceptual difference in length was possible between the lines on and off the wings.

Step (4) included the use of a bowl of water and a black wire to demonstrate the "bent" appearance of the wire in the water. Also, a tablespoon, paper dog cutout and magnifying glass were used to illustrate apparent inverted images.

Step (9) used the following conservation tasks:

a) length conservation

After acknowledging quantitative equivalence between the lengths of two strips of cardboard, the experimenter cut one strip into three parts and joined them together to form a letter N.

b) length conservation

Two cylinders of plasticine were juxtaposed to illustrate their equality in terms of length. One cylinder was then broken in half and the two pieces were joined to form a letter V.

c) mass

Two cakes of plasticine were juxtaposed then one of the balls was made into a cross.

d) mass

Two cakes of plasticine were juxtaposed then one was changed into a horseshoe.

e) area

Two sheets of paper were juxtaposed then one piece was cut into three triangles and the triangles were joined at one of their tips.

f) area

Two sheets of paper were juxtaposed and then one of the pieces was cut in half. The two halves were repositioned to form an upside-down letter V.

Throughout all of the steps used in the procedure the experimenter emphasized the presence of two conditions.

1. Effective communication between experimenter and subject with instant feedback.

2. Effective focusing on the relevant aspects of a situation. This factor was mainly fostered through the use of phenomenal-real discrimination as an orienting basis.

Pretests and posttests were identical to the Part I conservation tasks.

<u>Hypothesis IV</u>

$H_1$ - The treatment group will be significantly more successful on the conservation posttest than the control group.

$H_2$ - The treatment group will be significantly more successful than the control group on a conservation transfer test.

$H_3$ - The treatment group will be significantly more successful than the control group on conservation retention tests.

## Data Analysis IV

### Hypotheses 1 and 2

Hypotheses 1 and 2 were tested using a chi square for two independent samples (incorporating a correction for continuity--Siegel, 1956). The results as indicated in Table XXV supported both hypotheses.

TABLE XXVI

COMPARISON OF TREATMENT AND CONTROL GROUPS ON THE CONSERVATION POSTESTS

CONSERVATION TASKS

| | LENGTH | | AREA | | MASS | | LIQUID (Transfer) | |
|---|---|---|---|---|---|---|---|---|
| | + | - | + | - | + | - | + | - |
| T | 16 | 4 | 16 | 4 | 16 | 4 | 15 | 5 |
| C | 0 | 20 | 0 | 20 | 0 | 20 | 0 | 20 |
| | $X^2 = 23.44$ | | $X^2 = 23.44$ | | $X^2 = 23.44$ | | $X^2 = 20.91$ | |

T - Treatment group    .05 - 3.84
C - Control group    .01 - 6.64

### Hypothesis 3

Hypothesis 3 was tested using a chi square for two independent samples (incorporating a correction for continuity). The treatment and control groups were tested for retention of conservation at periods of two and six weeks after the training session. The results as indicated in Table XXVI supported the hypothesis.

TABLE XXVII

COMPARISON OF TREATMENT AND CONTROL GROUPS
ON THE CONSERVATION RETENTION TASKS

(2 weeks) CONSERVATION TASKS

| | LENGTH + | LENGTH − | | AREA + | AREA − | | MASS + | MASS − | | LIQUID + | LIQUID − |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 16 | 4 | T | 16 | 4 | T | 16 | 4 | T | 15 | 5 |
| C | 0 | 20 | C | 0 | 20 | C | 0 | 20 | C | 0 | 20 |

$X^2 = 23.44$ $X^2 = 23.44$ $X^2 = 23.44$ $X^2 = 20.91$

(6 weeks)

| | LENGTH + | LENGTH − | | AREA + | AREA − | | MASS + | MASS − | | LIQUID + | LIQUID − |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 15 | 4 | T | 15 | 4 | T | 15 | 4 | T | 14 | 5 |
| C | 1 | 17 | C | 0 | 18 | C | 2 | 16 | C | 0 | 18 |

T - Treatment group
C - Control group
.05 - 3.84
.01 - 6.64

Reliability and Validity IV

Several of the points concerning the reliability and validity of Part IV are identical to those discussed in Reliability and Validity, Part I. Additional points concerning the reliability and validity of Part IV are inherent in the procedure for Part IV. The conservation of liquid quantity was used as a transfer task because from the pretests of Part I and Part IV, it was evident that of the four types of conservation tasks used (length, area, mass and liquid quantity) the tasks concerned with liquid quantity appeared to be the

most difficult. The subjects who passed some of the other conservation tasks never passed the liquid tasks.

Although the transfer and retention tests indicated results that were consistent with the posttests further reliability could have been provided by having other experimenters in addition to the author give the retention tests. However, since no person qualified in the administration of Piagetian conservation tasks was available (person familiar with the theoretical and procedural aspects) the author did not have another experimenter give the retention tasks. It was considered, however, that as a result of seven of the treatment subjects correctly explaining the conservation problems to their mothers (experimenter questioned the parents about whether the subjects discussed the training experiment before he gave the retention tests to the subjects) additional reliability was provided in this respect. On the posttests another experimenter classified the treatment group into conservers and nonconservers (from tape recording data). A 100% agreement was reached between the author's and the other person's classification. The tasks used in the training session were different from the pretest and posttest tasks in that the objects used for the conservation tests were different in color and/or shape. The incorporation of a control group was carried out as follows:

| Pretest | Training | Posttest | Retention 1 and 2 |
|---|---|---|---|
| 20 subjects (treatment) | 20 subjects (treatment) | 20 subjects (treatment) | (treatment) |
| 20 subjects (control) | | 20 subjects (control) | (control) |

Discussion IV

The results of the training session support the rationale developed in Chapter III--Part IV of the thesis. The author feels that as a result of the findings, further research should be carried out with younger subjects using a similar rationale. It appears that the difference between the conserver and nonconserver is not so much the presence of "logical operations" (in the Piagetian sense, Piaget, 1968) in the conserver which are not refined in the nonconserver as it is a difference in discrimination. The nonconserver lacks a refinement in his discrimination of quantitative and perceptual attributes which the conserver had attained. The original associations learned by the nonconserver (in terms of quantitative and perceptual attributes) are ambiguous and thus are as much a cause of the nonconserver's failure on conservation tasks as they are necessary precursors to the child's attainment of conservation. The most effective means of fostering a refinement in the ambiguous associations held by the nonconservers (see Chapter III--Part IV) seems to be a guided learning situation where relevant attributes of a problem are emphasized as well as where the irrelevant attributes are de-emphasized. Only in this way can the ambiguous associations of the nonconserver be refined so that quantitative changes are discriminated independently from perceptual changes. The author is in full agreement with such approaches to training for conservation as proposed by Gelman (1967) and Zimiles (1963). A training session which attempts to foster conservation acquisition by de-emphasizing the effect of misleading perceptual cues is only approaching half of the problem. The nonconserver as a

result of such a training session has every legitimate right to continue giving nonconservation responses after the training session since the training session itself has not given a conclusive argument against the nonconserver's response. Similarly, a training session which is designed to foster conservation by emphasizing the transformations involved in the conservation tasks is also only attacking half of the problem but probably the more important half as Berlyne (1965) has discussed. It is no wonder that so many of the training attempts which have emphasized some particular factor have been unsuccessful in fostering conservation. The author feels the most encouraging approaches to fostering conservation acquisition will lie in the studies which emphasize the nature of quantitative transformations and de-emphasize the role of misleading perceptual cues in a mutual coherent manner (see Chapter III--Part IV).

It is further felt that the distinction between phenomenal and "real" properties of objects is an effective means for fostering an orientation on the part of the subject towards quantitative and perceptual aspects involved in conservation tasks. Phenomenal-real discrimination provides an effective dichotomous categorization in which the experimenter can embark on training the subject for conservation.

# CHAPTER V

## SUMMARY, IMPLICATIONS AND RECOMMENDATIONS

### Part I

Evidence was found that nonconservers gave their responses to conservation tasks both in terms of the state attributes (perceptual features) of the objects concerned and in terms of the transformations performed on the objects. Instances were observed where the non-conserver's assertion of quantitative inequality between particular objects was reversed from conservation tasks to stage C tasks (see Chapter IV--Part I). This was interpreted as evidence in support of the hypothesis that even though perceptually one object may be considered to be quantitatively greater than another object, occassionally the opposite object would be chosen as being quantitatively greater when striking transformations such as "cutting" were included. The results of Part I were interpreted as being in support of a contention that for conservation training to be effective, the experimenter must emphasize the misleading aspects of perception as well as the purely quantitative aspects of certain transformations in a unified manner. An attempt to use such a rationale was demonstrated in Part IV of the research.

The experimenter feels that the results of Part I are interesting enough to recommend further studies in the area. In particular, similar research to that conducted in Part I should be

carried out for more types of conservation tasks as well as for various modifications of particular tasks. Larger samples would illustrate trends (if such trends were present) to a more significant degree.

Part II

In terms of number and separation of corneal reflections, age and conservation status groups did not show any significant differences during scanning of the Muller-Lyer illusion. All groups however, were significant in distributing their fixations unequally over the four quadrants of the stimulus. Also, all groups significantly reduced the number of their fixations over trials of stimulus presentation. The results were considered as initial findings to be further analyzed in terms of a different definition of fixation incorporating a variable latency. It was hypothesized that the results were indicative of a possible scanning strategy where an initial, careful examination of one of the lines on the Muller-Lyer illusion was followed by a short comparison (matching response) to the other line.

It is recommended by the experimenter that studies of eye movements during the visual examination of the Muller-Lyer illusion be supplemented with studies of illusion strength. The use of the Muller-Lyer illusion as a visual stimulus for comparing the perceptual activity of conservers and nonconservers was used because it displayed a phenomenal-real discrepancy in length without having any other perceptual factor such as differential position of lines contaminating the length discrepancy.

Part III

The results of Part III indicated that for the age range of six and one half to nine and one half years both conservers and nonconservers possessed phenomenal-real discrimination. The findings indicated that the relationship between conservation and phenomenal-real discrimination need not be direct (as previously hypothesized by Braine and Shanks, 1965). The results however, were in support of the author's contention that although a meaningful relationship may exist between phenomenal-real discrimination and conservation additional factors must intervene. The presence of a large group of nonconservers who possessed phenomenal-real discrimination laid a basis for the attempt to use phenomenal-real discrimination as an orienting basis in training for conservation acquisition in Part IV of the thesis. It is recommended that younger subjects be tested on phenomenal-real discrimination and conservation.

Part IV

An intervention study proved successful in training sixteen out of twenty subjects in the treatment group, while in the control group none attained conservation on the posttests. The results were interpreted as supporting a rationale developed by the author (Chapter III--Part IV) that an emphasis on quantitative transformations coupled with an emphasis on the misleading character of perceptual cues would be successful in fostering conservation in nonconservers. The training technique emphasized the factors of effective communication and proper focusing on relevant aspects of a situation. The latter factor was

emphasized with having phenomenal-real discrimination act as an orienting basis for conservation acquisition.

It is recommended by the author that similar studies be carried out using more than one training period as well as younger subjects. Furthermore, the training technique could be adapted to a group situation.

It was concluded that the difference between nonconservation and conservation involved that attainment of a more refined discrimination between purely quantitative transformations and transformations contaminated with perceptual changes. The attainment of conservation was interpreted as not necessarily involving the intervention of logical operations in the Piagetian sense.

# CHAPTER VI

## PILOT STUDIES

### Part I

To investigate the feasibility of not obtaining differences in responses to conservation and stage C tasks due to the order of task presentation sixteen subjects were divided into two equal groups and given the conservation and stage C tasks in alternate orders. The subjects were between the ages of six and nine years and all subjects were female. The results, as tested by chi square, indicated no differences in responses to the conservation and stage C tasks as a result of the order of task presentation. The conservation and stage C tasks were similar to the tasks used in Part I of the thesis. Since differences due to order effects could have contaminated the comparison of responses to the conservation and stage C tasks the above study was deemed advisable.

An interesting observation was made in carrying out the above pilot study which lead to formulations for Part IV of the thesis. It was observed that on questioning the nonconservers about the reasons for their answers to the conservation tasks (also asking them if anything was added or taken away after the transformation was completed on one of the objects) they immediately answered "no" (that nothing was added or taken away). This was the same observation that Piaget (1960) made when testing his subjects but the experimenter could not

come to a conclusion similar to that of Piaget's about why the nonconservers were capable of an "identity" response and yet consistently fail the conservation tasks. The "identity" answers of the conservers and nonconservers were so similar that the experimenter had to conclude that the nonconservers were really as capable of a logical explanation as the conservers but that for some reason they were not making use of such an explanation. The experimenter's interpretation of the above observations and the incorporation of the resultant ideas into Part IV of the thesis were explained in Chapter III--Part IV.

Part II and III

The age range of the subjects and their sex was partly determined by two observations in the pilot work associated with Part II and III of the thesis. It was found that females were less distractible than males with respect to the apparatus associated with Part II of the study. The age range was partly determined as a result of subjects younger than six years of age failing some of the phenomenal-real discrimination tasks involved with Part III of the thesis. Since it was important to have subjects for Part IV of the thesis that possessed phenomenal-real discrimination the age range of the sample was cut off at a point where the probability was quite high that most of the subjects would possess phenomenal-real discrimination.

As a reliability check on the Muller-Lyer illusion stimulus used in Part II of the thesis (in terms of whether the subjects would be as susceptible to the illusion when presented in the setting of the

eye movement apparatus as they would be at an ordinary desk presentation) twenty subjects were given the illusion stimulus (as well as the subsequent four stimuli following the presentation of the illusion stimulus--see Part II, procedure) at a desk presentation and twenty subjects were tested with the stimulus in the experimental setting of Part II. A 100% agreement was observed between the two groups in terms of susceptibility to the illusion and changes in responses to the additional four stimuli.

As a result of observing the pilot study subjects respond to different slides of the Muller-Lyer illusion (black lines on a white background and white lines on a black background) it was felt that slides containing black lines on a white background were more vivid in terms of visual clarity.

An important observation made with regard to the successive and simultaneous presentation of the verbal instructions and illusion stimulus with pilot subjects was that the calibration and recording of the eye movements was much less reliable with a successive presentation (verbal instructions first followed by the presentation of the illusion stimulus). What occurred with the successive presentation of the instructions and illusion stimulus was that strong "orienting reactions" were evident right after the verbal instructions ceased and the calibration slide was replaced (causing a temporary black screen) by the illusion stimulus. The subjects responded to the previous instructions and the following black screen by shifting their gaze in a searching manner. In terms of the eye movement camera it appeared to the experimenter (operating the camera) that the subject's

fixations were off calibration so readjustments in the camera co-ordinates were carried out. However such readjustments were not successful since with the emergence of the illusion stimulus the subject returned his gaze to the stimulus on the screen. It was then impossible to determine whether the subject was on calibration all the time (with just a temporary shift in gaze) or whether the readjustments of the camera co-ordinates corrected the decalibration caused during the orienting reaction. Even when the experimenters did not readjust the co-ordinates (so that the subject's gaze eventually returned to the screen) the interval between hearing the instructions and being able to examine the illusion stimulus was too great to maintain good attention on the part of the subject. Although subjects could have been exposed to several trial runs of the experimental procedure with different questions and stimuli (to cause habituation to the interval between verbal instruction and the emergence of the stimulus on the screen) the experimenter felt such a procedure would take too much time. Instead, the simultaneous presentation of the verbal instructions and the visual stimulus was incorporated resulting in a much superior procedure in terms of maintaining the subject's attention as well as in reinforcing good calibration.

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# APPENDIX

# APPENDIX A

## Symbols

| VARIABLE CODE | IDENTIFICATION | VALUE CODE |
|---|---|---|
| S# | Subject Number | |
| AM | Chronological Age (Months) | |
| AG | Age group | |
| IQ | Detroit Beginners Test (mental age--months) | |
| BS | Blishen Scale rating | |
| SC | Selected Conservation Status Group | 1--Conserver<br>0--Nonconserver<br>2--omitted |
| OG | Order group | 1--Conservation first<br>2--Conservation second |
| LC | Conservation of Length | 1--Conserver<br>0--Nonconserver |
| AC | Conservation of Area | 1--Conserver<br>0--Nonconserver |
| MC | Conservation of Mass | 1--Conserver<br>0--Nonconserver |
| QC | Conservation of Liquid quantity | 1--Conserver<br>0--Nonconserver |
| TC | Treatment-Control (Part IV) | 1--Treatment<br>0--Control<br>2--Omitted |

APPENDIX A - PART I RAW DATA

| S# | AM | AG | IQ | BS | SC | OG | LC | AC | MC | QC | TC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 090 | 1 | 120 | 577 | 2 | 1 | 1 | 0 | 0 | 0 | 2 |
| 02 | 090 | 1 | 102 | 432 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| 03 | 086 | 1 | 109 | 640 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 04 | 086 | 1 | 102 | 506 | 1 | 2 | 1 | 1 | 1 | 0 | 2 |
| 05 | 088 | 1 | 095 | 472 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| 06 | 090 | 1 | 101 | 472 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 07 | 081 | 1 | 098 | 507 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 08 | 086 | 1 | 094 | 416 | 2 | 2 | 0 | 1 | 1 | 0 | 2 |
| 09 | 077 | 1 | 111 | 576 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10 | 078 | 1 | 097 | 472 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 11 | 087 | 1 | 089 | 432 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 12 | 081 | 1 | 109 | 522 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 13 | 087 | 1 | 096 | 462 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 14 | 082 | 1 | 105 | 465 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 15 | 088 | 1 | 107 | 520 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 16 | 081 | 1 | 100 | 300 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 17 | 083 | 1 | 090 | 577 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| 18 | 077 | 1 | 102 | 432 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| 19 | 079 | 1 | 102 | 560 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| 20 | 083 | 1 | 089 | 622 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |
| 21 | 079 | 1 | 114 | 473 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 22 | 085 | 1 | 095 | 583 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 23 | 086 | 1 | 112 | 510 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 24 | 089 | 1 | 101 | 630 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 25 | 090 | 1 | 093 | 452 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 26 | 097 | 2 | 087 | 650 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| 27 | 098 | 2 | 103 | 560 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 28 | 099 | 2 | 088 | 622 | 1 | 1 | 1 | 1 | 1 | 0 | 2 |
| 29 | 090 | 2 | 104 | 300 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| 30 | 100 | 2 | 096 | 436 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 31 | 098 | 2 | 109 | 515 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 32 | 097 | 2 | 112 | 560 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 33 | 097 | 2 | 110 | 542 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 34 | 094 | 2 | 115 | 618 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 35 | 102 | 2 | 102 | 441 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| 36 | 102 | 2 | 106 | 458 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 37 | 097 | 2 | 087 | 504 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 38 | 091 | 2 | 110 | 494 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 39 | 100 | 2 | 104 | 434 | 2 | 2 | 0 | 1 | 1 | 0 | 2 |
| 40 | 090 | 2 | 099 | 436 | 0 | 2 | 0 | 1 | 0 | 0 | 0 |
| 41 | 089 | 2 | 109 | 472 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 42 | 098 | 2 | 108 | 430 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 43 | 100 | 2 | 104 | 445 | 0 | 1 | 0 | 0 | 1 | 0 | 2 |
| 44 | 099 | 2 | 099 | 472 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 45 | 094 | 2 | 098 | 472 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 46 | 102 | 2 | 101 | 472 | 0 | 2 | 0 | 0 | 1 | 0 | 2 |
| 47 | 099 | 2 | 109 | 416 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| 48 | 094 | 2 | 096 | 510 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |

| S# | AM | AG | IQ | BS | SC | OG | LC | AC | MC | QC | TC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 098 | 2 | 111 | 622 | 0 | 2 | 0 | 0 | 1 | 0 | 2 |
| 50 | 091 | 2 | 109 | 472 | 2 | 1 | 0 | 0 | 1 | 0 | 2 |
| 51 | 111 | 3 | 100 | 502 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 52 | 105 | 3 | 097 | 622 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 53 | 107 | 3 | 092 | 473 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 54 | 109 | 3 | 101 | 508 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 55 | 113 | 3 | 091 | 300 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 56 | 106 | 3 | 096 | 459 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 57 | 112 | 3 | 095 | 472 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 58 | 113 | 3 | 107 | 460 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 59 | 111 | 3 | 096 | 472 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 60 | 110 | 3 | 108 | 436 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 61 | 113 | 3 | 091 | 472 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 62 | 106 | 3 | 112 | 622 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 63 | 103 | 3 | 085 | 610 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 64 | 103 | 3 | 112 | 622 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 65 | 108 | 3 | 104 | 459 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 66 | 111 | 3 | 084 | 472 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| 67 | 109 | 3 | 114 | 441 | 2 | 1 | 1 | 0 | 0 | 0 | 1 |
| 68 | 107 | 3 | 101 | 475 | 2 | 2 | 1 | 0 | 1 | 1 | 2 |
| 69 | 106 | 3 | 103 | 436 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 70 | 111 | 3 | 109 | 455 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 71 | 102 | 3 | 111 | 472 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |
| 72 | 102 | 3 | 104 | 474 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 73 | 110 | 3 | 081 | 634 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 74 | 104 | 3 | 112 | 400 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| 75 | 102 | 3 | 106 | 458 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |

# APPENDIX B

## Symbols

| VARIABLE CODE | IDENTIFICATION | VALUE CODE |
|---|---|---|
| S# | Subject Number | |
| P | Position of Illusion | 1--arrow/feather<br>2--feather/arrow |
| V | Verbal instruction | 1--"long"<br>2--"short"<br>3--"same" |
| T | Trial of illusion presentation | |
| NF | Number of fixations | |
| TTL | Total Track length (millimeters) | |
| NT | Number of Tracks | |
| MTL | Mean track length | |

APPENDIX B - PART II RAW DATA

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 01 | 2 | 1 | 1 | 36 | 285 | 35 | 8.14 |
| 01 | 1 | 3 | 2 | 26 | 230 | 25 | 9.20 |
| 01 | 1 | 2 | 3 | 17 | 230 | 16 | 14.38 |
| 01 | 2 | 2 | 4 | 29 | 530 | 28 | 18.93 |
| 01 | 1 | 1 | 5 | 30 | 450 | 29 | 15.52 |
| 01 | 2 | 3 | 6 | 41 | 695 | 40 | 17.38 |
| 02 | 1 | 3 | 1 | 99 | 1125 | 98 | 11.48 |
| 02 | 2 | 1 | 2 | 34 | 590 | 33 | 17.88 |
| 02 | 2 | 2 | 3 | 31 | 595 | 30 | 19.83 |
| 02 | 1 | 1 | 4 | 11 | 175 | 10 | 17.50 |
| 02 | 2 | 3 | 5 | 10 | 275 | 09 | 30.55 |
| 02 | 1 | 2 | 6 | 10 | 85 | 09 | 9.44 |
| 03 | 1 | 1 | 1 | 90 | 1070 | 89 | 12.02 |
| 03 | 1 | 3 | 2 | 27 | 335 | 26 | 12.89 |
| 03 | 1 | 2 | 3 | 10 | 95 | 09 | 10.56 |
| 03 | 2 | 1 | 4 | 15 | 190 | 14 | 13.57 |
| 03 | 2 | 2 | 5 | 15 | 145 | 14 | 10.36 |
| 03 | 2 | 3 | 6 | 16 | 130 | 15 | 8.67 |
| 04 | 1 | 2 | 1 | 55 | 765 | 54 | 14.17 |
| 04 | 2 | 3 | 2 | 85 | 1005 | 84 | 11.96 |
| 04 | 2 | 2 | 3 | 60 | 810 | 59 | 13.73 |
| 04 | 1 | 3 | 4 | 79 | 950 | 78 | 12.18 |
| 04 | 1 | 1 | 5 | 68 | 990 | 67 | 14.78 |
| 04 | 2 | 1 | 6 | 48 | 680 | 47 | 14.47 |
| 05 | 1 | 1 | 1 | 43 | 515 | 42 | 12.26 |
| 05 | 1 | 3 | 2 | 23 | 345 | 22 | 15.68 |
| 05 | 2 | 2 | 3 | 48 | 650 | 47 | 13.83 |
| 05 | 1 | 2 | 4 | 35 | 405 | 34 | 11.91 |
| 05 | 2 | 1 | 5 | 27 | 480 | 26 | 18.46 |
| 05 | 2 | 3 | 6 | 35 | 380 | 34 | 11.18 |
| 06 | 2 | 3 | 1 | 71 | 910 | 70 | 13.00 |
| 06 | 1 | 2 | 2 | 81 | 985 | 80 | 12.31 |
| 06 | 2 | 2 | 3 | 69 | 860 | 68 | 12.67 |
| 06 | 1 | 3 | 4 | 52 | 780 | 51 | 15.29 |
| 06 | 2 | 1 | 5 | 59 | 890 | 58 | 15.34 |
| 06 | 1 | 1 | 6 | 41 | 530 | 40 | 13.25 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 07 | 2 | 1 | 1 | 99 | 1315 | 98 | 13.42 |
| 07 | 1 | 2 | 2 | 60 | 1070 | 59 | 18.14 |
| 07 | 1 | 3 | 3 | 47 | 780 | 46 | 16.96 |
| 07 | 2 | 2 | 4 | 15 | 255 | 14 | 18.21 |
| 07 | 1 | 1 | 5 | 10 | 155 | 09 | 17.22 |
| 07 | 2 | 3 | 6 | 10 | 125 | 09 | 13.89 |
| 08 | 2 | 1 | 1 | 37 | 635 | 36 | 17.64 |
| 08 | 1 | 1 | 2 | 17 | 275 | 16 | 17.19 |
| 08 | 1 | 2 | 3 | 12 | 210 | 11 | 19.09 |
| 08 | 1 | 3 | 4 | 19 | 185 | 18 | 10.28 |
| 08 | 2 | 2 | 5 | 20 | 320 | 19 | 16.84 |
| 08 | 2 | 3 | 6 | 24 | 250 | 23 | 10.87 |
| 09 | 1 | 1 | 1 | 90 | 1135 | 89 | 12.75 |
| 09 | 1 | 3 | 2 | 14 | 140 | 13 | 10.77 |
| 09 | 2 | 2 | 3 | 44 | 520 | 43 | 12.09 |
| 09 | 2 | 3 | 4 | 31 | 450 | 30 | 15.00 |
| 09 | 1 | 2 | 5 | 45 | 620 | 44 | 14.09 |
| 09 | 2 | 1 | 6 | 30 | 935 | 29 | 32.24 |
| 10 | 2 | 1 | 1 | 55 | 420 | 54 | 7.77 |
| 10 | 1 | 3 | 2 | 25 | 390 | 24 | 16.25 |
| 10 | 1 | 2 | 3 | 43 | 570 | 42 | 13.57 |
| 10 | 1 | 1 | 4 | 47 | 790 | 46 | 17.17 |
| 10 | 2 | 3 | 5 | 39 | 545 | 38 | 14.34 |
| 10 | 2 | 2 | 6 | 62 | 1085 | 61 | 17.79 |
| 11 | 2 | 3 | 1 | 63 | 845 | 62 | 13.63 |
| 11 | 2 | 2 | 2 | 48 | 555 | 47 | 11.81 |
| 11 | 1 | 2 | 3 | 30 | 265 | 29 | 9.14 |
| 11 | 1 | 1 | 4 | 36 | 380 | 35 | 10.86 |
| 11 | 1 | 3 | 5 | 39 | 440 | 38 | 11.58 |
| 11 | 2 | 1 | 6 | 43 | 540 | 42 | 12.86 |
| 12 | 2 | 1 | 1 | 33 | 365 | 32 | 11.41 |
| 12 | 2 | 3 | 2 | 37 | 495 | 36 | 13.75 |
| 12 | 1 | 1 | 3 | 25 | 245 | 24 | 10.21 |
| 12 | 2 | 2 | 4 | 28 | 440 | 27 | 16.30 |
| 12 | 1 | 2 | 5 | 20 | 425 | 19 | 22.37 |
| 12 | 1 | 3 | 6 | 18 | 280 | 17 | 16.47 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 13 | 1 | 2 | 1 | 31 | 280 | 30 | 9.33 |
| 13 | 1 | 3 | 2 | 17 | 160 | 16 | 16.00 |
| 13 | 2 | 2 | 3 | 40 | 745 | 39 | 19.10 |
| 13 | 2 | 3 | 4 | 66 | 1080 | 65 | 16.62 |
| 13 | 1 | 1 | 5 | 54 | 580 | 53 | 10.94 |
| 13 | 2 | 1 | 6 | 55 | 750 | 54 | 13.89 |
| 14 | 1 | 3 | 1 | 62 | 835 | 61 | 13.69 |
| 14 | 1 | 1 | 2 | 25 | 410 | 24 | 17.08 |
| 14 | 2 | 1 | 3 | 37 | 505 | 36 | 14.03 |
| 14 | 2 | 3 | 4 | 20 | 230 | 19 | 12.11 |
| 14 | 2 | 2 | 5 | 42 | 510 | 41 | 12.44 |
| 14 | 1 | 2 | 6 | 15 | 370 | 14 | 26.43 |
| 15 | 2 | 2 | 1 | 97 | 1205 | 96 | 12.55 |
| 15 | 1 | 2 | 2 | 43 | 680 | 42 | 16.19 |
| 15 | 2 | 3 | 3 | 23 | 340 | 22 | 15.45 |
| 15 | 1 | 3 | 4 | 34 | 525 | 33 | 15.90 |
| 15 | 2 | 1 | 5 | 26 | 400 | 25 | 16.00 |
| 15 | 1 | 1 | 6 | 25 | 370 | 24 | 15.42 |
| 16 | 1 | 3 | 1 | 30 | 390 | 29 | 13.45 |
| 16 | 1 | 1 | 2 | 36 | 430 | 35 | 12.29 |
| 16 | 2 | 3 | 3 | 28 | 265 | 27 | 9.82 |
| 16 | 2 | 1 | 4 | 27 | 350 | 26 | 13.46 |
| 16 | 1 | 2 | 5 | 26 | 315 | 25 | 12.60 |
| 16 | 2 | 2 | 6 | 30 | 350 | 29 | 12.09 |
| 17 | 1 | 1 | 1 | 35 | 405 | 34 | 11.91 |
| 17 | 1 | 2 | 2 | 78 | 520 | 77 | 6.75 |
| 17 | 2 | 1 | 3 | 70 | 645 | 69 | 9.35 |
| 17 | 2 | 2 | 4 | 60 | 710 | 59 | 12.03 |
| 17 | 1 | 3 | 5 | 32 | 310 | 31 | 10.00 |
| 17 | 2 | 3 | 6 | 39 | 390 | 38 | 10.26 |
| 18 | 1 | 1 | 1 | 36 | 480 | 35 | 13.71 |
| 18 | 2 | 1 | 2 | 40 | 540 | 39 | 13.85 |
| 18 | 1 | 3 | 3 | 31 | 420 | 30 | 14.00 |
| 18 | 2 | 2 | 4 | 34 | 480 | 33 | 14.55 |
| 18 | 1 | 2 | 5 | 36 | 490 | 35 | 14.00 |
| 18 | 2 | 3 | 6 | 25 | 300 | 24 | 12.50 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 19 | 1 | 2 | 1 | 32 | 370 | 31 | 11.94 |
| 19 | 1 | 1 | 2 | 46 | 680 | 45 | 15.11 |
| 19 | 2 | 1 | 3 | 38 | 405 | 37 | 10.95 |
| 19 | 2 | 2 | 4 | 50 | 635 | 49 | 12.96 |
| 19 | 1 | 3 | 5 | 51 | 560 | 50 | 11.20 |
| 19 | 2 | 3 | 6 | 33 | 300 | 32 | 9.38 |
| 20 | 2 | 3 | 1 | 35 | 475 | 34 | 13.97 |
| 20 | 1 | 3 | 2 | 42 | 600 | 41 | 14.63 |
| 20 | 2 | 1 | 3 | 41 | 495 | 40 | 12.38 |
| 20 | 1 | 1 | 4 | 34 | 515 | 33 | 15.61 |
| 20 | 1 | 2 | 5 | 32 | 395 | 31 | 12.74 |
| 20 | 2 | 2 | 6 | 32 | 525 | 31 | 16.94 |
| 21 | 1 | 2 | 1 | 55 | 950 | 54 | 17.59 |
| 21 | 2 | 2 | 2 | 53 | 975 | 52 | 18.75 |
| 21 | 1 | 1 | 3 | 33 | 770 | 32 | 24.10 |
| 21 | 2 | 1 | 4 | 22 | 555 | 21 | 26.42 |
| 21 | 1 | 3 | 5 | 26 | 365 | 25 | 14.60 |
| 21 | 2 | 3 | 6 | 32 | 535 | 31 | 17.25 |
| 22 | 2 | 1 | 1 | 90 | 1115 | 89 | 12.53 |
| 22 | 2 | 2 | 2 | 36 | 480 | 35 | 13.71 |
| 22 | 1 | 1 | 3 | 49 | 500 | 48 | 10.42 |
| 22 | 2 | 3 | 4 | 41 | 615 | 40 | 15.38 |
| 22 | 1 | 3 | 5 | 38 | 460 | 37 | 12.43 |
| 22 | 1 | 2 | 6 | 31 | 380 | 30 | 12.67 |
| 23 | 2 | 1 | 1 | 43 | 825 | 42 | 19.64 |
| 23 | 1 | 2 | 2 | 33 | 430 | 32 | 13.44 |
| 23 | 1 | 1 | 3 | 32 | 695 | 31 | 22.42 |
| 23 | 2 | 2 | 4 | 42 | 770 | 41 | 18.78 |
| 23 | 1 | 3 | 5 | 30 | 405 | 29 | 13.97 |
| 23 | 2 | 3 | 6 | 35 | 480 | 34 | 14.12 |
| 24 | 1 | 2 | 1 | 34 | 595 | 33 | 18.03 |
| 24 | 2 | 3 | 2 | 39 | 610 | 38 | 16.05 |
| 24 | 1 | 3 | 3 | 34 | 455 | 33 | 13.79 |
| 24 | 2 | 1 | 4 | 32 | 540 | 31 | 17.42 |
| 24 | 1 | 1 | 5 | 32 | 520 | 31 | 16.77 |
| 24 | 2 | 2 | 6 | 30 | 350 | 29 | 12.07 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 25 | 1 | 1 | 1 | 43 | 450 | 42 | 10.71 |
| 25 | 2 | 3 | 2 | 34 | 505 | 33 | 15.30 |
| 25 | 1 | 3 | 3 | 27 | 520 | 26 | 20.00 |
| 25 | 2 | 2 | 4 | 35 | 420 | 34 | 12.35 |
| 25 | 2 | 1 | 5 | 45 | 385 | 44 | 8.75 |
| 25 | 1 | 2 | 6 | 27 | 420 | 26 | 16.15 |
| 26 | 2 | 2 | 1 | 38 | 720 | 37 | 19.46 |
| 26 | 2 | 1 | 2 | 41 | 700 | 40 | 17.50 |
| 26 | 1 | 2 | 3 | 36 | 595 | 35 | 17.00 |
| 26 | 1 | 3 | 4 | 44 | 670 | 43 | 15.88 |
| 26 | 1 | 1 | 5 | 41 | 560 | 40 | 14.00 |
| 26 | 2 | 3 | 6 | 16 | 190 | 15 | 12.67 |
| 27 | 1 | 2 | 1 | 45 | 675 | 44 | 15.34 |
| 27 | 2 | 3 | 2 | 35 | 575 | 34 | 16.91 |
| 27 | 1 | 3 | 3 | 45 | 595 | 44 | 13.52 |
| 27 | 1 | 1 | 4 | 47 | 660 | 46 | 14.35 |
| 27 | 2 | 1 | 5 | 32 | 380 | 31 | 12.26 |
| 27 | 2 | 2 | 6 | 30 | 460 | 29 | 15.86 |
| 28 | 2 | 2 | 1 | 55 | 960 | 54 | 17.77 |
| 28 | 1 | 2 | 2 | 65 | 940 | 64 | 14.68 |
| 28 | 1 | 3 | 3 | 50 | 825 | 49 | 16.83 |
| 28 | 2 | 3 | 4 | 47 | 685 | 46 | 14.89 |
| 28 | 1 | 1 | 5 | 43 | 515 | 42 | 12.26 |
| 28 | 2 | 1 | 6 | 26 | 385 | 25 | 15.40 |
| 29 | 1 | 3 | 1 | 35 | 475 | 34 | 13.97 |
| 29 | 2 | 2 | 2 | 34 | 420 | 33 | 12.72 |
| 29 | 1 | 1 | 3 | 28 | 280 | 27 | 10.37 |
| 29 | 1 | 2 | 4 | 26 | 335 | 25 | 13.48 |
| 29 | 2 | 1 | 5 | 42 | 660 | 41 | 16.10 |
| 29 | 2 | 3 | 6 | 12 | 215 | 11 | 19.54 |
| 30 | 1 | 3 | 1 | 45 | 590 | 44 | 13.47 |
| 30 | 1 | 1 | 2 | 40 | 540 | 39 | 13.84 |
| 30 | 2 | 1 | 3 | 37 | 260 | 36 | 7.22 |
| 30 | 1 | 2 | 4 | 40 | 380 | 39 | 9.74 |
| 30 | 2 | 3 | 5 | 35 | 420 | 34 | 12.35 |
| 30 | 2 | 2 | 6 | 32 | 360 | 31 | 11.69 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 31 | 1 | 1 | 1 | 43 | 580 | 42 | 13.84 |
| 31 | 2 | 2 | 2 | 44 | 465 | 43 | 10.87 |
| 31 | 1 | 3 | 3 | 53 | 550 | 52 | 10.60 |
| 31 | 2 | 3 | 4 | 36 | 450 | 35 | 12.85 |
| 31 | 2 | 1 | 5 | 33 | 455 | 32 | 14.22 |
| 31 | 1 | 2 | 6 | 29 | 280 | 28 | 10.00 |
| 32 | 2 | 3 | 1 | 74 | 1260 | 73 | 17.26 |
| 32 | 2 | 2 | 2 | 45 | 695 | 44 | 15.79 |
| 32 | 1 | 3 | 3 | 34 | 540 | 33 | 16.36 |
| 32 | 1 | 2 | 4 | 35 | 580 | 34 | 17.05 |
| 32 | 1 | 1 | 5 | 38 | 275 | 37 | 7.43 |
| 32 | 2 | 1 | 6 | 29 | 315 | 28 | 11.25 |
| 33 | 1 | 3 | 1 | 48 | 735 | 47 | 15.64 |
| 33 | 1 | 2 | 2 | 33 | 515 | 32 | 16.10 |
| 33 | 2 | 3 | 3 | 30 | 465 | 29 | 16.03 |
| 33 | 2 | 1 | 4 | 26 | 485 | 25 | 19.40 |
| 33 | 2 | 2 | 5 | 46 | 590 | 45 | 13.11 |
| 33 | 1 | 1 | 6 | 27 | 360 | 26 | 13.85 |
| 34 | 1 | 3 | 1 | 39 | 495 | 38 | 13.03 |
| 34 | 2 | 3 | 2 | 35 | 610 | 34 | 17.94 |
| 34 | 1 | 2 | 3 | 32 | 525 | 31 | 16.94 |
| 34 | 1 | 1 | 4 | 20 | 295 | 19 | 15.53 |
| 34 | 2 | 2 | 5 | 23 | 285 | 22 | 12.95 |
| 34 | 2 | 1 | 6 | 39 | 445 | 38 | 13.10 |
| 35 | 2 | 3 | 1 | 35 | 580 | 34 | 17.05 |
| 35 | 1 | 3 | 2 | 31 | 615 | 30 | 20.50 |
| 35 | 2 | 1 | 3 | 33 | 505 | 32 | 15.78 |
| 35 | 2 | 2 | 4 | 25 | 375 | 24 | 15.62 |
| 35 | 1 | 2 | 5 | 32 | 465 | 31 | 15.00 |
| 35 | 1 | 1 | 6 | 37 | 710 | 36 | 19.72 |
| 36 | 1 | 2 | 1 | 57 | 825 | 56 | 14.76 |
| 36 | 2 | 2 | 2 | 44 | 845 | 43 | 19.65 |
| 36 | 1 | 3 | 3 | 35 | 560 | 34 | 16.47 |
| 36 | 2 | 3 | 4 | 20 | 435 | 19 | 22.89 |
| 36 | 2 | 1 | 5 | 20 | 185 | 19 | 9.73 |
| 36 | 1 | 1 | 6 | 28 | 405 | 27 | 15.00 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 37 | 2 | 3 | 1 | 94 | 1395 | 93 | 15.00 |
| 37 | 1 | 2 | 2 | 88 | 1460 | 87 | 16.78 |
| 37 | 1 | 3 | 3 | 16 | 230 | 15 | 15.33 |
| 37 | 2 | 1 | 4 | 68 | 890 | 67 | 13.28 |
| 37 | 2 | 2 | 5 | 18 | 360 | 17 | 21.17 |
| 37 | 1 | 1 | 6 | 28 | 435 | 27 | 16.11 |
| 38 | 1 | 1 | 1 | 61 | 940 | 60 | 15.67 |
| 38 | 2 | 3 | 2 | 32 | 635 | 31 | 20.48 |
| 38 | 2 | 1 | 3 | 76 | 1065 | 75 | 14.20 |
| 38 | 1 | 3 | 4 | 37 | 395 | 36 | 10.97 |
| 38 | 2 | 2 | 5 | 29 | 435 | 28 | 15.36 |
| 38 | 1 | 2 | 6 | 19 | 265 | 18 | 14.72 |
| 39 | 1 | 2 | 1 | 40 | 755 | 39 | 19.36 |
| 39 | 2 | 1 | 2 | 45 | 790 | 44 | 17.95 |
| 39 | 2 | 2 | 3 | 57 | 830 | 56 | 14.82 |
| 39 | 2 | 3 | 4 | 55 | 945 | 54 | 17.50 |
| 39 | 1 | 3 | 5 | 31 | 465 | 30 | 15.50 |
| 39 | 1 | 1 | 6 | 27 | 590 | 26 | 22.69 |
| 40 | 2 | 1 | 1 | 61 | 645 | 60 | 10.75 |
| 40 | 2 | 2 | 2 | 37 | 330 | 36 | 9.17 |
| 40 | 1 | 2 | 3 | 37 | 415 | 36 | 11.53 |
| 40 | 1 | 1 | 4 | 48 | 515 | 47 | 10.96 |
| 40 | 1 | 3 | 5 | 33 | 390 | 32 | 12.19 |
| 40 | 2 | 3 | 6 | 33 | 255 | 32 | 7.97 |
| 41 | 1 | 2 | 1 | 39 | 610 | 38 | 16.05 |
| 41 | 2 | 1 | 2 | 40 | 525 | 39 | 13.46 |
| 41 | 2 | 3 | 3 | 40 | 510 | 39 | 13.08 |
| 41 | 1 | 3 | 4 | 35 | 410 | 34 | 12.06 |
| 41 | 1 | 1 | 5 | 37 | 460 | 36 | 12.78 |
| 41 | 2 | 2 | 6 | 34 | 530 | 33 | 16.06 |
| 42 | 1 | 3 | 1 | 36 | 375 | 35 | 10.71 |
| 42 | 2 | 1 | 2 | 30 | 340 | 29 | 11.72 |
| 42 | 2 | 2 | 3 | 25 | 365 | 24 | 15.21 |
| 42 | 1 | 1 | 4 | 46 | 455 | 45 | 10.11 |
| 42 | 2 | 3 | 5 | 25 | 245 | 24 | 10.21 |
| 42 | 1 | 2 | 6 | 26 | 425 | 25 | 9.00 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 43 | 1 | 3 | 1 | 46 | 630 | 45 | 14.00 |
| 43 | 2 | 2 | 2 | 51 | 825 | 50 | 16.50 |
| 43 | 2 | 1 | 3 | 63 | 985 | 62 | 15.89 |
| 43 | 1 | 2 | 4 | 54 | 780 | 53 | 14.72 |
| 43 | 1 | 1 | 5 | 30 | 360 | 29 | 12.41 |
| 43 | 2 | 3 | 6 | 52 | 610 | 51 | 11.96 |
| 44 | 2 | 2 | 1 | 39 | 410 | 38 | 10.79 |
| 44 | 1 | 3 | 2 | 60 | 810 | 59 | 13.73 |
| 44 | 1 | 2 | 3 | 51 | 415 | 50 | 8.30 |
| 44 | 2 | 1 | 4 | 63 | 510 | 62 | 8.23 |
| 44 | 1 | 1 | 5 | 43 | 375 | 42 | 8.93 |
| 44 | 2 | 3 | 6 | 26 | 175 | 25 | 7.00 |
| 45 | 1 | 3 | 1 | 34 | 475 | 33 | 14.39 |
| 45 | 2 | 3 | 2 | 37 | 550 | 36 | 15.28 |
| 45 | 1 | 2 | 3 | 42 | 515 | 41 | 12.56 |
| 45 | 1 | 1 | 4 | 37 | 455 | 36 | 12.64 |
| 45 | 2 | 2 | 5 | 45 | 530 | 44 | 12.05 |
| 45 | 2 | 1 | 6 | 25 | 470 | 24 | 19.58 |
| 46 | 2 | 2 | 1 | 41 | 640 | 40 | 16.00 |
| 46 | 1 | 3 | 2 | 67 | 890 | 66 | 13.48 |
| 46 | 1 | 1 | 3 | 27 | 355 | 26 | 13.65 |
| 46 | 2 | 1 | 4 | 32 | 495 | 31 | 15.96 |
| 46 | 1 | 2 | 5 | 29 | 435 | 28 | 15.54 |
| 46 | 2 | 3 | 6 | 30 | 350 | 29 | 12.06 |
| 47 | 2 | 2 | 1 | 92 | 1035 | 91 | 11.37 |
| 47 | 1 | 2 | 2 | 39 | 730 | 38 | 19.21 |
| 47 | 1 | 1 | 3 | 26 | 480 | 25 | 19.20 |
| 47 | 1 | 3 | 4 | 34 | 535 | 33 | 16.21 |
| 47 | 2 | 1 | 5 | 32 | 480 | 31 | 15.48 |
| 47 | 2 | 3 | 6 | 34 | 375 | 33 | 11.36 |
| 48 | 2 | 2 | 1 | 37 | 535 | 36 | 14.86 |
| 48 | 2 | 3 | 2 | 103 | 160 | 12 | 13.33 |
| 48 | 1 | 1 | 3 | 30 | 460 | 29 | 15.86 |
| 48 | 2 | 1 | 4 | 25 | 475 | 24 | 19.79 |
| 48 | 1 | 3 | 5 | 28 | 335 | 27 | 12.41 |
| 48 | 1 | 2 | 6 | 43 | 475 | 42 | 11.31 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 49 | 2 | 1 | 1 | 43 | 605 | 42 | 14.40 |
| 49 | 1 | 3 | 2 | 60 | 710 | 59 | 12.03 |
| 49 | 2 | 3 | 3 | 43 | 505 | 42 | 12.02 |
| 49 | 1 | 2 | 4 | 34 | 460 | 33 | 13.94 |
| 49 | 2 | 2 | 5 | 36 | 505 | 35 | 14.43 |
| 49 | 1 | 1 | 6 | 52 | 840 | 51 | 16.47 |
| 50 | 2 | 1 | 1 | 36 | 410 | 35 | 11.71 |
| 50 | 1 | 2 | 2 | 17 | 185 | 16 | 11.63 |
| 50 | 1 | 3 | 3 | 12 | 245 | 11 | 22.27 |
| 50 | 1 | 1 | 4 | 12 | 190 | 11 | 17.27 |
| 50 | 2 | 3 | 5 | 12 | 225 | 11 | 20.45 |
| 50 | 2 | 2 | 6 | 12 | 230 | 11 | 20.91 |
| 51 | 2 | 1 | 1 | 48 | 450 | 47 | 9.57 |
| 51 | 1 | 3 | 2 | 31 | 550 | 30 | 18.33 |
| 51 | 1 | 2 | 3 | 28 | 475 | 27 | 16.96 |
| 51 | 2 | 2 | 4 | 35 | 570 | 34 | 16.77 |
| 51 | 2 | 3 | 5 | 34 | 460 | 33 | 13.93 |
| 51 | 1 | 1 | 6 | 26 | 320 | 25 | 12.80 |
| 52 | 1 | 3 | 1 | 37 | 680 | 36 | 18.88 |
| 52 | 2 | 1 | 2 | 38 | 730 | 37 | 19.73 |
| 52 | 1 | 2 | 3 | 48 | 1030 | 47 | 21.91 |
| 52 | 2 | 2 | 4 | 30 | 325 | 29 | 11.21 |
| 52 | 2 | 3 | 5 | 33 | 565 | 32 | 17.66 |
| 52 | 1 | 1 | 6 | 50 | 435 | 49 | 8.89 |
| 53 | 2 | 1 | 1 | 37 | 565 | 36 | 15.69 |
| 53 | 2 | 3 | 2 | 63 | 735 | 62 | 11.85 |
| 53 | 2 | 2 | 3 | 49 | 795 | 48 | 16.56 |
| 53 | 1 | 2 | 4 | 44 | 540 | 43 | 12.56 |
| 53 | 1 | 3 | 5 | 32 | 340 | 31 | 10.97 |
| 53 | 1 | 1 | 6 | 24 | 380 | 23 | 16.52 |
| 54 | 2 | 1 | 1 | 36 | 470 | 35 | 13.43 |
| 54 | 2 | 3 | 2 | 35 | 520 | 34 | 15.29 |
| 54 | 1 | 1 | 3 | 30 | 435 | 29 | 15.00 |
| 54 | 1 | 2 | 4 | 32 | 490 | 31 | 15.81 |
| 54 | 1 | 3 | 5 | 41 | 495 | 40 | 12.37 |
| 54 | 2 | 2 | 6 | 28 | 340 | 27 | 12.59 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 55 | 2 | 1 | 1 | 45 | 525 | 44 | 11.93 |
| 55 | 2 | 3 | 2 | 45 | 700 | 44 | 15.91 |
| 55 | 1 | 3 | 3 | 35 | 360 | 34 | 10.58 |
| 55 | 1 | 1 | 4 | 40 | 565 | 39 | 14.49 |
| 55 | 2 | 2 | 5 | 44 | 635 | 43 | 14.77 |
| 55 | 1 | 2 | 6 | 32 | 395 | 31 | 12.74 |
| 56 | 2 | 1 | 1 | 56 | 655 | 55 | 11.91 |
| 56 | 1 | 1 | 2 | 56 | 915 | 55 | 16.64 |
| 56 | 2 | 2 | 3 | 34 | 625 | 33 | 18.94 |
| 56 | 1 | 2 | 4 | 10 | 160 | 09 | 17.77 |
| 56 | 2 | 3 | 5 | 10 | 100 | 09 | 11.11 |
| 56 | 1 | 3 | 6 | 10 | 110 | 09 | 12.22 |
| 57 | 1 | 3 | 1 | 86 | 1000 | 85 | 11.76 |
| 57 | 2 | 2 | 2 | 49 | 645 | 48 | 13.44 |
| 57 | 2 | 1 | 3 | 79 | 850 | 78 | 10.90 |
| 57 | 2 | 3 | 4 | 63 | 725 | 62 | 11.69 |
| 57 | 1 | 1 | 5 | 30 | 680 | 29 | 23.45 |
| 57 | 1 | 2 | 6 | 68 | 940 | 67 | 14.03 |
| 58 | 2 | 3 | 1 | 76 | 1050 | 75 | 14.00 |
| 58 | 2 | 1 | 2 | 50 | 745 | 49 | 15.20 |
| 58 | 1 | 1 | 3 | 42 | 590 | 41 | 14.39 |
| 58 | 1 | 3 | 4 | 43 | 790 | 42 | 18.81 |
| 58 | 2 | 2 | 6 | 36 | 595 | 35 | 17.00 |
| 58 | 1 | 2 | 6 | 55 | 670 | 54 | 12.40 |
| 59 | 1 | 2 | 1 | 42 | 525 | 41 | 12.80 |
| 59 | 1 | 3 | 2 | 35 | 570 | 34 | 16.76 |
| 59 | 2 | 1 | 3 | 35 | 575 | 34 | 16.91 |
| 59 | 1 | 1 | 4 | 25 | 325 | 24 | 13.54 |
| 59 | 2 | 2 | 5 | 35 | 530 | 34 | 15.59 |
| 59 | 2 | 3 | 6 | 40 | 435 | 39 | 11.15 |
| 60 | 1 | 3 | 1 | 35 | 500 | 34 | 14.70 |
| 60 | 1 | 1 | 2 | 49 | 570 | 48 | 11.88 |
| 60 | 1 | 2 | 3 | 65 | 745 | 64 | 11.64 |
| 60 | 2 | 2 | 4 | 53 | 590 | 52 | 11.32 |
| 60 | 2 | 3 | 5 | 67 | 685 | 66 | 10.38 |
| 60 | 2 | 1 | 6 | 55 | 650 | 54 | 12.04 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 61 | 1 | 3 | 1 | 35 | 525 | 34 | 15.44 |
| 61 | 2 | 2 | 2 | 35 | 550 | 34 | 16.18 |
| 61 | 1 | 2 | 3 | 37 | 485 | 36 | 13.47 |
| 61 | 2 | 3 | 4 | 32 | 525 | 31 | 16.94 |
| 61 | 2 | 1 | 5 | 39 | 530 | 38 | 13.95 |
| 61 | 1 | 1 | 6 | 35 | 565 | 34 | 16.62 |
| 62 | 1 | 2 | 1 | 30 | 520 | 29 | 17.93 |
| 62 | 1 | 1 | 2 | 31 | 565 | 30 | 18.83 |
| 62 | 2 | 3 | 3 | 36 | 500 | 35 | 14.28 |
| 62 | 1 | 3 | 4 | 21 | 320 | 20 | 16.00 |
| 62 | 2 | 1 | 5 | 33 | 410 | 32 | 12.81 |
| 62 | 2 | 2 | 6 | 28 | 550 | 27 | 20.37 |
| 63 | 2 | 1 | 1 | 36 | 455 | 35 | 13.00 |
| 63 | 1 | 1 | 2 | 32 | 410 | 31 | 13.22 |
| 63 | 2 | 2 | 3 | 34 | 425 | 33 | 12.88 |
| 63 | 2 | 3 | 4 | 38 | 580 | 37 | 15.68 |
| 63 | 1 | 2 | 5 | 46 | 600 | 45 | 13.33 |
| 63 | 1 | 3 | 6 | 23 | 480 | 22 | 21.81 |
| 64 | 2 | 3 | 1 | 40 | 505 | 39 | 12.95 |
| 64 | 2 | 1 | 2 | 36 | 520 | 35 | 14.86 |
| 64 | 2 | 2 | 3 | 36 | 340 | 35 | 9.71 |
| 64 | 1 | 1 | 4 | 37 | 420 | 37 | 11.67 |
| 64 | 1 | 3 | 5 | 33 | 415 | 32 | 12.97 |
| 64 | 1 | 2 | 6 | 39 | 520 | 38 | 13.68 |
| 65 | 1 | 2 | 1 | 49 | 590 | 48 | 12.29 |
| 65 | 1 | 1 | 2 | 41 | 665 | 40 | 16.63 |
| 65 | 2 | 1 | 3 | 37 | 385 | 36 | 10.69 |
| 65 | 1 | 3 | 4 | 44 | 465 | 43 | 10.81 |
| 65 | 2 | 3 | 5 | 45 | 400 | 44 | 9.09 |
| 65 | 2 | 2 | 6 | 29 | 425 | 28 | 15.18 |
| 66 | 2 | 3 | 1 | 42 | 520 | 41 | 12.68 |
| 66 | 1 | 1 | 2 | 27 | 380 | 26 | 14.62 |
| 66 | 1 | 2 | 3 | 37 | 495 | 36 | 13.75 |
| 66 | 2 | 1 | 4 | 36 | 450 | 35 | 12.86 |
| 66 | 1 | 3 | 5 | 30 | 315 | 29 | 10.86 |
| 66 | 2 | 2 | 6 | 27 | 550 | 26 | 21.15 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 67 | 1 | 1 | 1 | 35 | 615 | 34 | 18.09 |
| 67 | 2 | 3 | 2 | 33 | 820 | 32 | 25.66 |
| 67 | 1 | 2 | 3 | 23 | 420 | 22 | 19.09 |
| 67 | 2 | 1 | 4 | 25 | 565 | 24 | 23.54 |
| 67 | 2 | 2 | 5 | 29 | 560 | 28 | 20.00 |
| 67 | 1 | 3 | 6 | 33 | 470 | 32 | 14.69 |
| 68 | 2 | 2 | 1 | 30 | 300 | 29 | 10.34 |
| 68 | 2 | 1 | 2 | 10 | 100 | 09 | 11.11 |
| 68 | 1 | 1 | 3 | 23 | 480 | 22 | 21.82 |
| 68 | 2 | 3 | 4 | 45 | 615 | 44 | 13.98 |
| 68 | 1 | 2 | 5 | 32 | 530 | 31 | 17.10 |
| 68 | 1 | 3 | 6 | 22 | 350 | 21 | 16.66 |
| 69 | 1 | 1 | 1 | 36 | 615 | 35 | 17.57 |
| 69 | 2 | 2 | 2 | 37 | 615 | 36 | 17.08 |
| 69 | 1 | 2 | 3 | 53 | 700 | 52 | 13.46 |
| 69 | 2 | 3 | 4 | 27 | 415 | 26 | 15.96 |
| 69 | 2 | 1 | 5 | 31 | 510 | 30 | 17.00 |
| 69 | 1 | 3 | 6 | 43 | 475 | 42 | 11.31 |
| 70 | 2 | 2 | 1 | 36 | 805 | 35 | 23.00 |
| 70 | 2 | 1 | 2 | 42 | 1210 | 41 | 29.51 |
| 70 | 2 | 3 | 3 | 30 | 520 | 29 | 17.93 |
| 70 | 1 | 1 | 4 | 33 | 620 | 32 | 19.38 |
| 70 | 1 | 2 | 5 | 35 | 630 | 34 | 18.53 |
| 70 | 1 | 3 | 6 | 20 | 405 | 19 | 21.32 |
| 71 | 1 | 3 | 1 | 69 | 1480 | 68 | 21.76 |
| 71 | 1 | 2 | 2 | 19 | 325 | 18 | 18.06 |
| 71 | 1 | 1 | 3 | 10 | 175 | 09 | 19.44 |
| 71 | 2 | 2 | 4 | 13 | 315 | 12 | 26.25 |
| 71 | 2 | 3 | 5 | 18 | 360 | 17 | 21.18 |
| 71 | 2 | 1 | 6 | 22 | 495 | 21 | 23.57 |
| 72 | 1 | 2 | 1 | 46 | 745 | 45 | 16.56 |
| 72 | 2 | 2 | 2 | 43 | 750 | 42 | 17.86 |
| 72 | 2 | 1 | 3 | 31 | 440 | 30 | 14.67 |
| 72 | 1 | 3 | 4 | 54 | 690 | 53 | 13.02 |
| 72 | 2 | 3 | 5 | 33 | 390 | 32 | 12.12 |
| 72 | 1 | 1 | 6 | 25 | 315 | 24 | 13.13 |

| S# | P | V | T | NF | TTL | NT | MTL |
|---|---|---|---|---|---|---|---|
| 73 | 2 | 1 | 1 | 85 | 1215 | 84 | 14.46 |
| 73 | 2 | 2 | 2 | 62 | 645 | 61 | 10.57 |
| 73 | 1 | 3 | 3 | 75 | 740 | 74 | 10.00 |
| 73 | 2 | 3 | 4 | 40 | 450 | 39 | 11.54 |
| 73 | 1 | 2 | 5 | 50 | 490 | 49 | 10.00 |
| 73 | 1 | 1 | 6 | 32 | 270 | 31 | 8.71 |
| 74 | 1 | 2 | 1 | 41 | 705 | 40 | 17.63 |
| 74 | 2 | 2 | 2 | 33 | 600 | 32 | 18.75 |
| 74 | 2 | 1 | 3 | 56 | 875 | 55 | 15.91 |
| 74 | 2 | 3 | 4 | 28 | 490 | 27 | 18.14 |
| 74 | 1 | 3 | 5 | 56 | 835 | 55 | 15.18 |
| 74 | 1 | 1 | 6 | 35 | 720 | 34 | 21.18 |
| 75 | 2 | 3 | 1 | 42 | 635 | 41 | 15.49 |
| 75 | 1 | 1 | 2 | 29 | 425 | 28 | 15.19 |
| 75 | 2 | 1 | 3 | 29 | 405 | 28 | 14.46 |
| 75 | 1 | 2 | 4 | 30 | 455 | 29 | 15.86 |
| 75 | 1 | 3 | 5 | 28 | 425 | 27 | 15.75 |
| 75 | 2 | 2 | 6 | 29 | 540 | 28 | 19.29 |